Teaching of Science in Secondary Schools

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FOREWORD

The National Council for Teacher Education has developed a curriculum framework for teacher education at all levels. The framework recommends that methods of teaching should be taught along with the content of subjects In other words, emphasis has been placed on the illustration of methodology with sufficient content units, each methodology being demonstrated by the teacher-educator before it is practised by the teacher-trainees. In order that the idea may be successfully tried out in teacher education institutions, it was decided to develop suitable material for the teaching of content-cum-methodology as a practical subject in teacher training institutions. The present volume is an attempt to develop a book for the teaching of science for use in secondary teacher training colleges

The book was developed by a project team, consisting of the faculty drawn from the Departments of Teacher Education and Education in Science and Mathematics of the NCERT and the faculty members of the four Regional Colleges of Education. Two British experts, Dr. C R Sutton of the School of Education, Leicester, and Dr. John O. Head, Chelsea College, London, also worked with the project team in a workshop which was organized for developing the book.

I am thankful to the Department of Teacher Education for taking up this project I am particularly thankful to Dr. C.R Sutton and Dr. John O. Head for their collaboration in this project and to the British Council for making their services available I am thankful to the members of the project team for developing this book and particularly to Shri K.B Gupta, Dr. R D Shukla and Dr. R. N. Mathur for editing the units on Biology, Chemistry and Physics respectively, in this book

I hope the book will be useful to science teacher-educators as well as teacher-trainees and will promote similar efforts by other institutions engaged in teacher education. Suggestions for improvement of this book would be welcome

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July 9, 1980

PREFACE

At present, in the teacher training colleges in the country, methodology of teaching science is taught as a theoretical subject. The techniques and approaches that are recommended for teaching of science are discussed in general terms without reference to the content

Most of the teacher training colleges in the country do not have a well-equipped science laboratory where practical experiments can be performed. It is presumed that the teacher trainees have learnt enough content—both theory and practical—in the science subjects in their bachelor's degree course in science and so no further discussion of content or performance of experiments is needed in the teacher training colleges

It is also presumed that the teacher-trainees will be able to decide which techniques and approaches are to be used in different units and they will be able to apply conveniently the principles of methodology while teaching in the classroom. Experienced teacher-educators, however, know that this presumption is not correct and the teacher-trainees are deficient in the content as well as in the practical work related to the teaching of science in the school. They are also unable to use the appropriate methodology in teaching the different units. For several years, it has been recommended by teacher-educators that both content and methodology should be taught together in the teacher training colleges, but no suitable books have been developed to help the teacher-educators in this task. As such, the teacher-educators find it difficult to integrate content and methodology in the training of teachers

This difficulty in teacher training was further emphasised in the *National Council's* publication, *Teacher Education Curriculum—A Framework*. It recommended that methodologies of teaching should be taught as a practical subject and both content and methodology should be integrated. In order to help the teacher-educators in accomplishing this task, the Department of Teacher Education took up a project to develop a book on the teaching of science in the secondary schools, integrating content with methodology. Since the NCERT with its four regional colleges of education has experienced teacher-educators in the field of science, it was decided that the book should be developed by a Project Team consisting of these experienced teacher-educators of the NCERT. The Project Team was inspired by the publications of the *Science Teacher Education Project* (*STEP*) of Britain However, it undertook to develop, in the first instance, one book which is more or less a textbook for the teaching of science methodology-cum-content, in the teacher training colleges.

Thus, while the Project Team thoroughly used the publications of STEP as reference material together with many other publications such as the materials of PSSC, Chem. Study, etc, they had to make a judicious selection of items of content and methodological approaches so as to limit the volume of the book and at the same time include the main concepts of idaas that are to be developed by science teacher educators in training science teachers for the secondary schools. A careful study was made of the secondary and higher secondary syllabuses in science subjects recommended by the NCERT to determine the main units of content, on which the book is to be written.

The question, whether to develop the book on the basis of different methodological approaches using content as illustrations or to develop it significantly according to the content and bringing in methodology while discussing the content, was a difficult one to decide. The Team, however, felt that it would be better to present the units significantly according to the content and to preserve the interrelationship between the contents, and the methodologies may be brought in to each item of content. In such a project, there is a danger that some particular approaches and methodologies may be often repeated, while some other approaches and methodologies may receive little attention. Even though care has been taken to see that various approaches and methodologies have been reflected in different units, it is only when the book is used that the shortcomings, if any, can be revealed. These shortcomings will be rectified in the next edition of the book

For using the book, it is presumed that at least six hours per week should be devoted for the teaching of content-cum-methodology in science It is suggested that the teacher-educator may ask the teacher-trainees to read a unit in advance and come prepared for discussion in the class room. He may then discuss the main concepts and the methodological approaches that may be used in teaching these concepts. The teacher-trainees may be divided into small groups for practice of simulated teaching of these units, using the approaches and methodologies discussed. They should also perform the necessary additional assignments indicated in the book, individually or in small groups. This is the content-cum-methodology-cum-practical approach advocated in this book.

The book has been divided into four parts In the first part, some general topics regarding the nature and process of science and the approaches that may be used in the teaching of science have been indicated. This is followed by three sections on Biology, Chemistry and Physics In each section, some important units of the secondary schools syllabus have been dealt with and the main concepts involved therein are discussed, indicating the methodology that may be used while teaching these concepts It is presumed that all the sections of the book will be used for training the teacher in the teaching of science in secondary schools. However, if a teacher-training college has physical science and biological science as separate methodology subjects, then the respective parts of the book, together with the first general part, can be used in the respective methodology subjects. It is also presumed that the training colleges will try to

develop a well-equipped science laboratory by availing themselves of financial assistance from the University Grants Commission or from other sources It is also hoped that in due course, the training colleges will have teacher-educators in science—one in Physical Science and one in Biological Science—so that they can handle the content and methodology efficiently

This book has been developed as an experimental edition at the first instance. It is hoped that a large number of teacher training colleges in the country would come forward to use the book in training teachers in the teaching of science. The Department of Teacher Education would welcome suggestions regarding its improvement from the teacher-educators and the teacher-trainees who had used this book. These suggestions will be duly considered in developing the next revised edition of the book

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July 7, 1980

CONTENTS

CHAPTER 1

Teaching and the Nature of Science

The impact of science and technology is visible everywhere. Science has influenced every aspect of man's existence—vocational, social, economic, political, and cultural. Science is intimately related to the means of production and means of communication, including transport. In turn, it influences the public both as a consumer and as a citizen. In such situations it is essential to understand science. Today, an understanding of science is useful to live successfully. But, for gainful employment in the fields of science and technology, it is essential to acquire specialized knowledge in one of the branches of science In other words, it can be said that to understand one's environment and to become a partner in the growth of science and technology, it is essential to acquire specialised knowledge of science. Hopefully, it will make a person scientifically literate citizen who can live efficiently and can take proper decisions.

Therefore, the youth today need scientific knowledge to understand the nature of the planet on which they live and its relationship to the rest of the universe. Every citizen should have adequate knowledge about the physical and biological world around him in order to take intelligent decisions, and for attacking and solving personal as well as environmental problems.

As a student-teacher it is expected that you have an understanding of the physical and biological world around you and, as one of the science teachers in the near future, you have to develop it among your pupils. In this effort you will be helping your pupils in acquiring scientific concepts and in seeing the structure which connects them. It has, therefore, become imperative on your part to understand the nature of science.

If you simply teach science by telling them what is in the books you do injustice

to your pupils because you are simply stuffing them with accumulated knowledge and not providing any opportunity to them for seeking new knowledge. To understand it properly, we need to understand the nature of science. Do you know what is the nature of science ? Can you distinguish between various forms of knowledge ? Specifically, can you distinguish between the nature of history and of science ? Do you know the methodologies used in acquiring scientific knowledge or historical facts ? If not, let us do this exercise in this chapter.

Try to write down how would you explain to a 12-year old boy what science is, and how scientists work
Ask a fellow student to do the same
Exchange your papers and compare them.

It is difficult to bring out this difference between different fields of knowledge, but it is evident that science is different from other forms of knowledge because it has to meet reality tests, that is, ideas have to correspond to our perceived reality of the world This characteristic has given a chance to science to minimize subjective opinions and to establish objectivity and rationality But how does this happen ? You may be assuming a complex mechanism for such an activity But it is not so. Science establishes its objectivity through observation, experimentation, formulation of hypotheses and their testing and then by drawing relevant inferences. It follows from this description that scientific beliefs are essentially independent of cultural and geographical factors. A scientific statement can be checked by experiment by anybody, anywhere in the world. You can make such checks. It is open to further experimentation, and in the light of new evidence it may be modified and changed. Hence, scientific concepts are generated by the workers going through the processes of science. Scientific concepts are developed while conducting laboratory work and field study. This can be schematically explained as follows

Process → concept → process → concept → Processes. These processes build a body of scientific knowledge and it continues to search the unknown. Thus, science is a self renewing, self-correcting and self-generating process

In these paragraphs we have outlined the nature of science which may be further classified by two simple yet pedagogically relevant explanations

A study of the definition of science given by Hurd in 1969 will be helpful in determining different aspects of science . "Facts in themselves simply do not make a science. Science is not simply an abstraction from empirical data, but an intellectual creation often suggested by data It is the discovery of order among the data that makes the science Science is an intellectual activity which arises from personal experience and takes place in the minds of men. It is simply a way of using human intelligence to achieve a better understanding of nature and nature's laws".

If you analyse the above mentioned definition of science, you may find two statements describing science :

(*a*) Science involves methods of inquiry or processes of science.
(*b*) This inquiry results in a body of a systematized knowledge or content or concepts.

These statements may be summarized thus .

Science = methods + knowledge
Or = inquiry + concepts
Or = Different methodologies of science + concepts which represent the body of scientific knowledge.

Now it is possible to infer that the nature of science includes not only concepts or content but also the methodologies which are used to find out these concepts. Thus, continuous search of new knowledge helps in building a body of that knowledge.

In the last two decades similar attempts have been made to determine the nature of science. Some of the intellectuals in the field have tried to conceptualize the nature of science. Joseph J. Schwab (1964) and Bruner (1962) have contributed in this field. It has been concluded that to understand the nature of science it can be divided into two parts :

(*a*) Substantive structure of science
(*b*) Syntactical structure of science.

The substantive structure of science represents the major conceptual schemes which constitute the basic knowledge used in science This substantive structure of science contains different classes of statement : definitions, knowledge-statements, direct observation statements, instrumental observation statements, theory statements, etc. We may call them 'key concepts', 'major concepts', 'representative ideas', etc. You can study such conceptual themes or major concepts while studying Biological Sciences Curriculum Study Project, Physical Science Study Committee Project, Chemistry Study Project and the Nuffield—Science Teaching Scheme, where all content revolves round certain major conceptual schemes.

The syntactical structure of science is concerned with the so-called processes of scientific inquiry; means by which scientific knowledge is acquired and verified.

Now you can infer that the nature of science comprises two aspects : concepts of science, which build the body of scientific knowledge and the processes of science, the methods by which scientists search new knowledge and solve problems.

Probably in your own learning of science you have come across mainly the '*content*' of science, 'body of knowledge', 'concepts', 'principles' and rarely you would have experienced the thrill of becoming an investigator, a scientist, by conducting experiments or doing the processes of science. It means you were experiencing only one part of the total process and missing the second and more important part, that is, the methodologies through which new knowledge is developed.

It has been suggested by workers in the field that the teaching and learning of science should be consistent with the nature of science. It will help you to understand the structure of science in the form of major concepts (substantive structure) and modes of thinking, reasoning and methodologies of searching for new knowledge (syntactical structure), rather than science as a collection of conclusions.

It is assumed that "teaching which emphasizes the structure of knowledge results in better learning (i.e. more efficient), or more retentive, or more highly motivated) than teaching which does not".

This discussion leads to another significant aspect of science teaching regarding methodologies. Many questions crop up immediately. You must be thinking : Which

method is most suitable for science teaching? Should I select and use only one method—Inquiry? Should I use demonstration or a film or a project work? Should I use team teaching or programmed-learning or individualized instruction?

The questions regarding methodology shall be viewed in the context of the need of the subject, need of pupils and your own background. Bruner (1966) has given three modes of learning and storing knowledge in the brain. These modes of learning are :

(*a*) Enactive—Learning through body; learning by doing; riding a bicycle or swimming, etc.
(*b*) Iconic —Learning by seeing.
(*c*) Symbolic—Verbal and book learning.

A very young child will learn principally by the enactive mode but as he grows older, the iconic and then the symbolic become more important. Nevertheless, even with adults the enactive and iconic forms are still important and probably people understand comprehensively and remember more easily if all the three modes can be employed at the same time with respect to the same topic.

In that event the science teacher has an advantage compared to the teachers of most other subjects as it is possible to give pupils opportunities to experience by enactive means. Therefore pupils should be allowed to *see* colour changes, shapes, sizes, movements, precipitations, etc. They should *feel* weights, forces, and temperature changes. They can *smell* gases. In that way their learning will be enhanced as they associate the enactive activity with the symbolic knowledge contained in books and lectures.

To use these methodologies on a simple scale you may ask pupils to observe and study the environment, because science is an attempt to make more sense out of one's environment, manipulating portions of that environment, recording the observations and inferring conclusions.

Another simple example to use some processes of science is to study different types of leaves, pebbles and marbles. Ask your pupils to observe and study the similarities. It will lead the pupils from *observation* to *classification* and finally they will be able to develop their own criteria for classifying the things You can ask them to classify plants on the campus or animals in the zoo but they should use their own reasoning to complete the assignment. Hopefully, they will get a feel of science. They will develop interest in science and scientific activities.

It is easy to pass on factual knowledge or conclusions of science through verbal communication. 'Chalk and talk' method is also very convenient to pass on scientific information to pupils. It is also easy to summarize a lot of knowledge through the lecture method. But it is not consistent with the nature of science. You have to practise and use a variety of activities which are relevant for learning science

By completing the following table you should focus attention on the methods which are most appropriate for achieving specific outcomes

Method ↓	*Aim* →	*Learning Facts*	*Gaining Skills*	*Motivation*	*Understanding Environment*	*Developing Hypotheses*
Teacher talk						
Teacher demonstration						
Pupils do experiment						
Observation						
Project work						
Small group activity						
Lab. Work						
Field trip						
Pupils do investigations						

(Please tick boxes to show method not relevant to aims)

You can further elaborate or extend this activity. You have to prepare a list of aims which may be achieved while using a specific methodology.

Learning science as an activity creates an opportunity for the learner to study science in its proper perspective, he can see science operationally, can use processes of science and can replace subjective opinions by beliefs based on empirical evidences You can check that statement against your own experience

Learning science as an activity has many psychological implications which are related to both learning and teaching. You can ask more questions which are likely to develop motivation and an interest in doing science. Improvement in the activity results in better understanding of the scientific phenomenon Active involvement of the learner is helpful in acquisition of skills. Learning science as an activity will prove useful not only in understanding science but also in building positive attitudes towards science and scientists.

ROLE OF THE SCIENCE TEACHER

You might have realized that it is due to traditional science teaching, where nature of science is not taken into consideration, pupils memorize the factual information and leave aside another part—inquiry (methods of searching knowledge). You can overcome it if you ask your pupils to do experiments or scientific activities, or deve-

lop hypotheses, or test hypotheses, or record and analyse scientific data In such situations your role as a science teacher will definitely change You will not function simply as a communicator of knowledge. You will work as an *activity facilitator*, or co-investigator Your role will be to function as a stage-setter and facilitator of learning where science teaching will resemble the science known by the scientists. Your responsibility is to stimulate proper learning-environment that facilitates, personal-investigation, small group activity, project work by pupils in ways that make sense to them Helping pupils to become confident and independent problem solvers (who continuously ask questions) is perhaps the most important responsibility you have. It is necessary on your part to practise some experiments, some investigatory projects, some improvisation and, above all, commitment to present science as science, not as history.

An Activity

Can you find any other definitions of Science ? Have a look at the list given below, and select those which you agree with, and those which you don't accept.

Science is built up with facts as a house is with stones. But a collection of facts is no more a science than a heap of stones is a house (J H. Poincare, 1885).

Science is first of all a set of attitudes It is disposition to deal with facts rather than with what someone has said about them (B.F. Skinner).

Science perfects genius and moderates that fury of fancy which cannot contain itself within the bounds of reason. (John Dryden, FRS, 17th century English poet).

It cannot be that the axioms established by argumentation can suffice for the discovery of new works, since the subtlety of nature is greater many times over than the subtlety of argument (Francis Bacon)

The belief that science proceeds from observation to theory is still so widely held that my denial of it is often met with incredulity (Karl Popper).

Science searches for relations which are thought to exist independently of the searching individual (Albert Einstein).

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CHAPTER 2

Objectives of Science Teaching

Societies in the developing countries are changing and every citizen has increasing contact with scientific knowledge and products of science and technology. For example, the use of fertilizers and medicines have become a part of life of the citizens. Science has direct influence on our citizens and it is related to their healthful living, the economy of our country and improvement of the environment. A housewife has to understand the purpose of healthy living, use of nutritional food items and population control. Similarly, a farmer has to understand proper use of improved seeds, fertilizers and insecticides. A worker should learn about electrically operated instruments.

Education in science is useful in dispelling superstition and creating a proper understanding of natural phenomenon Science has a special place in this century in

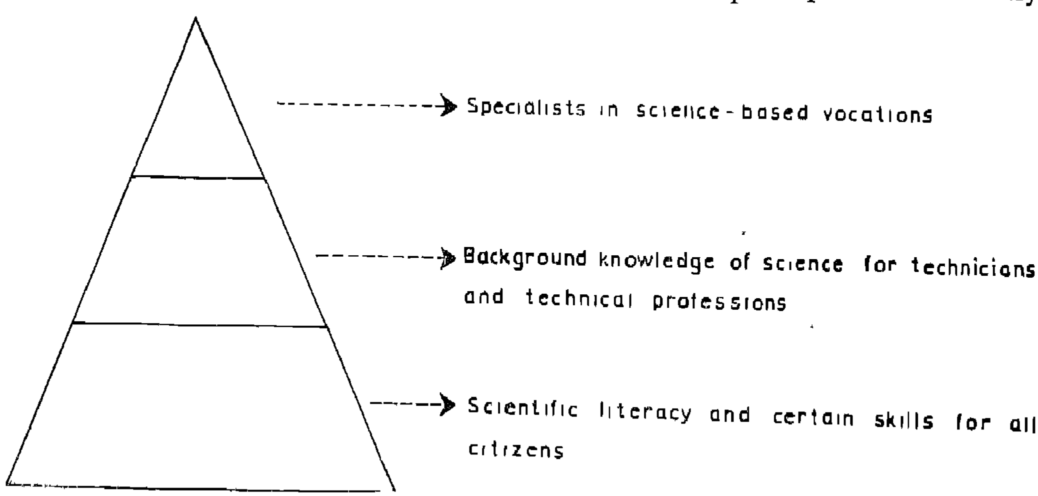

Fig. 2.1 Diagram showing purposes of science education

sharpening our power of reasoning and inculcating the values of truth and objectivity Education in science is needed by all—from the lay man to the specialist in industry.

Since you have received an education in science, it will be easy for you to appreciate the purposes of science education. A schematic diagram about the purposes of science will be helpful in clarifying your ideas.

It is evident that as in many areas of academic endeavour, education in science also helps promote intellectual curiosity and an understanding of the world we live in. Moving from scientific knowledge to the development of scientific attitudes is an important aim of science teaching. Since World War II, special emphasis has been given to the functional aspect of scientific knowledge and the acquisition of scientific skills. We can mention a list of such aims made by the committee which prepared the Forty-Sixth Yearbook of the National Society for the Study of Education in 1947, which was titled *Science Education in American Schools*. The committee proposed the following aims :

1. Functional information or facts of science
2. Functional concepts of science
3. Functional understanding of scientific principles
4. Instrumental skills
5. Problem-solving skills
6. Attitudes, such as .
   (*a*) openmindedness
   (*b*) intellectual honesty
   (*c*) suspended judgement.
7. Appreciation ·
   (*a*) Appreciation of the contribution of scientists
   (*b*) Appreciation of the basic cause-and-effect relationships
   (*c*) Sensitivity to possible uses and applications of science.
8. Interests :
   (*a*) Interest in some phases of science as recreational activity or hobby.
   (*b*) Interest in science as a vocation.

In Chapter 1 you have studied the nature of science and found that the objectives of science teaching are to be found in nature, philosophy, and history of science. We have seen that a scientifically literate person needs an understanding of the concepts of science and the acquisition of the processes of science in solving problems and making decisions. The following objectives of science teaching are consistent with the nature of science and we believe that students will realise them in order to be literate in science, and to appreciate its spirit and its basic concepts and to know how to use them for their own and society's benefit. These objectives are mentioned as follows along with their brief description :

I. To understand the meaning of basic concepts in science ,
II. to understand and acquire the processes of science ;
III. to understand the social aspects of science

I. Understand the meaning of basic concepts in Science : The facts, concepts and generalizations provide the content and knowledge in science. Facts are isolated pieces of information, but concepts are systems of classifying information and are generalised ideas. Concepts emerge through processes of science. Thus, concepts and processes are interrelated and interdependent. Some of the significant character-

istics of concepts are as follows :

(a) Concepts are generalized ideas.
(b) Concepts vary from simple to complex.
(c) Concepts are formed through varied experiences, including the acquisition of factual knowledge and activities.
(d) Concepts may be incomplete or complete, and as children grow up, their ideas become more and more complete.
(e) A concept is an abstraction to classify words, ideas and feelings, which have certain common qualities
(f) Concept learning is facilitated by learning through activity, in a variety of situations, and in a variety of contexts. Applying concepts in new situations strengthens the learning of the learner. Concepts have various dimensions and in their development they move along with these dimensions, i.e , from concrete to abstract, from vague to clear and from inexact to precise Concepts change along with other dimensions also.
(g) Recently, it has been put forth that conceptual learning is limited by one's developmental level. This has been suggested by Jean Piaget, a Swiss psychologist, engaged in cognitive development research. Piaget's main contribution to education has been his revelation of how children learn and how their mental growth proceeds. Some implications for learning science are as follows (Good, 1977) :

1. There are wide variations in developmental levels among children in most classrooms, thus, equally wide variations in their conceptual abilities.

2. Conceptual learning is tied closely to developmental level and occurs primarily as a result of a child's internalizing his or her own actions.

3. It appears that direct verbal instruction has little effect in facilitating advancement of developmental level and, thus, the ability of children to conceptualize problems is beyond their current developmental abilities.

Piaget thinks that encounters with experience is an essential factor in the development of intelligence All learning activities and experiences in science should be consistent with the developmental level of children. As a science teacher you would like to search relevant and purposeful activities to be introduced at a level understandable to the pupils.

In this book you will come across many concepts given in different chapters. Here, for the sake of clarity some examples of the concepts are given .

1. All living things grow and reproduce.
2. Living things vary in structure.
3. Objects float or sink because of their weight per unit volume (density).
4. Energy is needed to make things work more
5. Matter is made up of very small particles (molecules).

Do you know how to select concepts from the text ? If not, let us do this exercise in this chapter.

Try to list concepts from the textbook which you have to teach in the class. Exchange your notes and compare them.

II Understand and acquire the processes of Science : In learning science, pupils encounter many situations where they have to perform certain inquiry skills. Learning through these skills equips the pupils with abilities which may be useful in other contexts too, e g. the skill of making careful observation has a general utility and should facilitate the acquiring of concepts In simple situations pupils use simple observation skills, maybe through the naked eye. In some difficult situations pupils need to enlarge the capacity of observation through a microscope or telescope. In other situations, pupils need to conduct an experiment, record observations and draw relevant inferences. Pupils can predict on the basis of correct interpretation of data Such operations make up the processes of science. These have been practised by scientists in undertaking research and conducting experiments. These operations describe what scientists are supposed to do We hope that you will practice such operations while preparing for teaching You will expect that your pupils will pass through all such operations while learning science in your classroom. A list of the processes of science is given below.

1. Observation
2. Classification
3. Using numbers
4. Measurement
5 Using space-time and similar relationships
6. Communication
7. Inference
8. Prediction
9. Formulating hypotheses
10 Experimentation
11. Interpretation of data
12. Making operational definitions
13. Formulating theoretical models.

Just read these processes and imagine about their order of listing. These have been arranged in simple to difficult hierarchical order. Your pupils observe and classify things in their environment. Can you attempt such learning experience while teaching classification of plants and animals ?

III. Understand the social aspect of Science : Science learning helps in acquisition of concepts through processes But they should also understand that social factors influence the growth of science and that science affects the society Just try to remember the Green Revolution in India and relate it to the social aspects of science. Can you do that ? Similarly, pollution is often blamed on to science. Do you accept this hypothesis ? Why is there pollution in Madras, Delhi and Calcutta ? How do you relate population problems to science ? Can you use newspapers to determine the problems of pollution and population ?

Objectives of science teaching are useful when you, as a science teacher, internalize them, try to practice them, and try to develop them among your pupils.

For your teaching you will have to plan your own objectives, choose your own methods of teaching, but remember these should be consistent with the nature of science Just imparting information and neglecting the processes of science will imbalance your classroom teaching and you will be taking care of only one aspect of science.

A case history has been taken as an

illustration of the processes of science. This example has been taken from *How Children Discover Knowledge*, written by Narendra Vaidya.

Let us discuss the case history of Ronald Ross who worked on malaria. Ross was a doctor in the Indian Medical Service and had witnessed the loss of life caused by malaria. The cause of malaria was not known to anybody and different theories were suggested for it Such as drinking of water containing mosquito grubs, and biting by the mosquitoes Since then Ronald Ross tried to determine the cause. On return to India in 1889 he began his systematic investigations of mosquitoes by breeding them from larvae He discarded many theories regarding it and out of many species of mosquitoes he pinpointed his work on about five different malarial parasites. He dissected mosquito after mosquito and observed each of them under his improvised microscope He had with him about 30 potential cases of mosquitoes and on further close examination only three cases were left After many observations and experimentation, he observed some circular object with distinct black granules in it He did his usual routine of making sketches and taking notes. He had now one mosquito left. He now hypothesized that circular object he had noticed a little while ago, must grew overnight in the last remaining mosquito if it was a stage in the development of parasite He was now considering several alternatives at the same time. Next day he confirmed what he had hypothesized. He had now successfully traced the various stages of the parasite. He was in a state of ecstacy.

Can you record some of the processes practised by Ross? Why were these processes helpful in scientific work? Can you discover another such case history of a scientist?

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CHAPTER 3

How to Use this Book

Introduction

Is this just another teachers' guide for science teaching ? Definitely not. It is an attempt to translate theory into practice. In our country, science teaching is mostly theoretical and pupils learn science either from the verbal talk given by the science teacher or from the science textbook Pupils memorize factual information just to recall in the examination hall. No doubt many of them obtain commendable percentage of marks but do so without getting a genuine feel for science ; without being aware of the ecstasy of a scientist when he makes a new discovery. Why is this so ? There may be many reasons, but one of them is definitely related to the Science Teacher Education Programmes These programmes are usually theoretical and prospective science teachers just deliver forty lessons to qualify without attempting any innovation, without conducting any experiments, or relating teaching methods with the nature of science.

About this Book

This book is an attempt to relate teacher preparation practices with the nature of science with a hope that this process will further filter down to classroom teaching Hopefully, this will melt the barrier between theory and practice, because what science teachers practise will be further extended in the classroom

In this book the first two chapters discuss some ideas on the nature of sciences and the objectives of science teaching The first chapter presents a theoretical treatment of the nature of science and then show how the practical aspects lead to relevant methods of teaching. In Chapter 2, the objectives of teaching science have been discussed with a view that you as a science teacher will use processes of science and

will ask your pupils to do the same for acquiring the relevant concepts. Chapter 3 presents an outline for using this book. The remaining chapters provide a guideline for your work while you are studying at a college of education, and they also suggest school activities In these chapters content and method have been taken together and are organized in three stages, i.e., content, school-activities, student-teacher assignments, with an idea that student-teachers will learn about continuous interaction between theory and practice at the college as well as school levels.

How to Use this Book

Very often the methodology of teaching is treated separately from discussion of the content, which leaves it to the student-teacher to integrate the two areas. This book is unusual in the sense that the methodology is discussed with the content of science topics.

Essentially, each topic is divided into three parts : content, school activities and assignments for you to do while at college. We will discuss these three points in turn.

Content

Usually a brief list of relevant objectives and skills which are emphasised in the topic are listed. In addition to these are, of course, a number of objectives and skills which apply to all sections of the book. For example, the skills of assembling apparatus, making careful observation, recording and interpreting data, etc., come into almost all scientific activities. We do not, therefore, list them under each separate topic heading.

We outline briefly the key-concepts you will need to know to teach the topic in school. We do not go through all these concepts in detail, so you should check the list and if you feel unsure about some of them, then refer to the appropriate textbook or teachers' guide.

We then take one or two concepts and take them as examples to illustrate how the methodology links with the content.

School Activities

You, as a science teacher, have a wonderful opportunity to make teaching more exciting You can demonstrate experiments, use the local environment as a source of teaching material and ideas, and get the pupils to do practical work individually or in small groups.

Such work involves some prior thought and organization and that is why within each topic we have suggested in some detail which activities you might organize in a school. Sometimes you might feel discouraged by the lack of apparatus and facilities. Much good science can be done, however, even with the simplest equipment obtained from the local stores. Ingenuity and imagination are usually more important than more facilities.

Assignments

Within each topic a number of assignments for the student-teacher are suggested. They invite you to look at some of the issues and concepts in detail, which have not been fully discussed in the topic, and to practise specific skills, e.g in making models or improvising apparatus

You will not have enough time to do all these assignments Although you can only work through a selection of them, it would be worth while to read through the complete list to check the possibilities and see what can be done.

Some of the assignments involve the making of simple apparatus or the trying

out of new ideas. Do not be depressed by the difficulties you might find. It is better to try, even if the results are not as successful as you might like, than never to start. If you can discover yourself the satisfaction of experimentation in science you will be better able to pass on your enthusiasm to your pupils.

Notes for College Staff

In this book we are making new demands on the student-teachers and they will need support and encouragement in attempting to meet the demands.

Certainly there are implications for the way college work is organized If student-teachers are to explore different methods of teaching, then the best example is to demonstrate a variety of such methods at the college. The students should not be in a lecture room passively listening to a lecture. He should work together in small groups trying to solve a problem. Sometimes they will need access to simple workshop facilities equipped with some common hand tools so that they can try to improvise apparatus from everyday materials. Some other times, they should be encouraged to go out into their locality and see what resources for science teaching are available. The local flora, fauna and geology are obviously relevant. What about local industries? A local lime-kiln, iron-works or farm can serve as the basis for some good science teaching.

Facilities

It would facilitate this work if the method-cum-content work can be done in a flexible working space with movable tables and simple laboratory facilities and display space. We present below the plan of such a room.

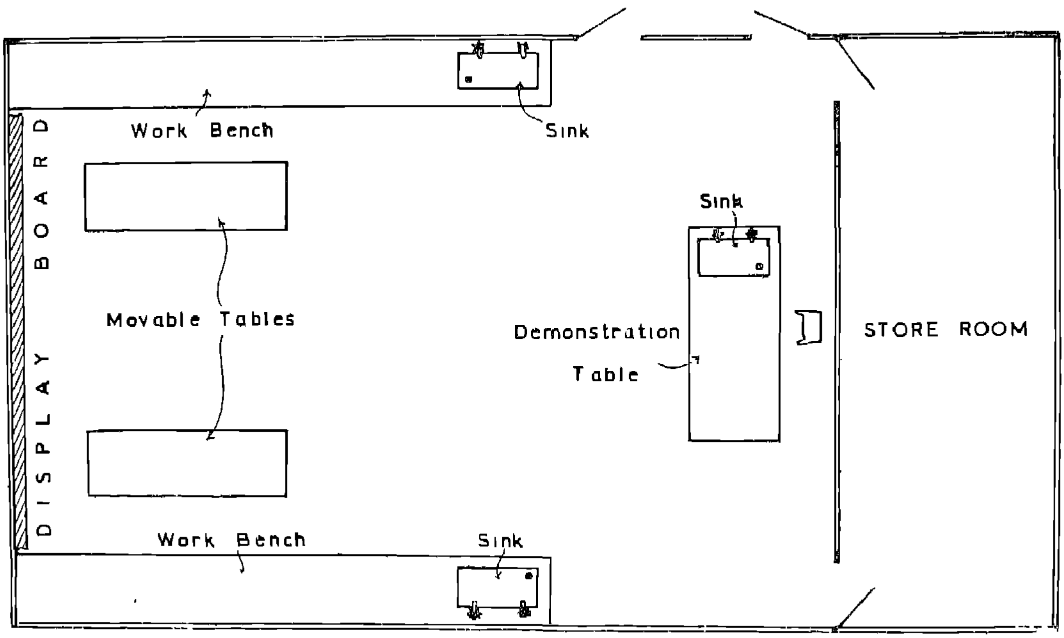

Fig. 3.1 Plan of a room with simple laboratory facilities

This room will need simple workshop tools such as saws for cutting wood, hammers, chisels, screws, nails, bolts, etc Such tools are available in many schools where science club is functioning.

Measurement

In such situations as discussed above, the role and procedure of evaluation will be different. The primary purpose of evaluation is to provide information for both teachers and pupils concerning the progress of the pupils and success of the teacher. You can develop simple objective type questions, but these should be constructed skilfully so that they can measure *what you want to measure*. It is recommended that for writing *objectives* for each topic you may consult *Taxonomy of Educational Objectives, Part I and Part II* by Benjamin S. Bloom and Associates, and *Preparing Instructional Objectives* by Robert F Mager.

It is also suggested that the observation of pupils' behaviour gives the teacher important clues to the achievement of learners In the laboratory we can test their practical skills and whether they are mastering the inquiry approach. For example, an experimental project or demonstration can be set up, or a diagram on the board, or a picture can be projected on the screen, or a paragraph describing an experiment can be distributed, and questions about the material can be asked in such a way that pupils demonstrate their ability to observe, formulate hypothesis, make predictions, record data and interpret results.

If student-teachers are to be encouraged to experiment and improvise within the content-cum-methodology course, then evaluation procedure should reflect this plan. The marks of student-teachers could be built up from the following.

(*a*) Teaching aids made, e.g. one which is two dimensional and one which is three dimensional ,

(*b*) Lesson planning note books ;

(*c*) A number of tests and assignments ;

(*d*) An examination, which will just be including recall questions, is not sufficient, but also should invite students to consider problems and exercise imagination and judgement in finding a solution

(*e*) Preparing improvised apparatus and conducting experiments.

As you start this book, we hope you will realize that this is not a conventional textbook on methods of teaching science but should help you acquire meaningful experiences to bridge the gap between theory and practice in science teaching.

CHAPTER 4

Living Things

Introduction

From their observations and experiences the students know that there are a variety of objects around them and that these are either living or non-living. They can readily recognise that a dog is a living thing and that a stone is not. A discussion on this topic can be initiated by asking them to name a few living and non-living things from their surroundings. Or else, you can make a list of some objects around the school and ask them to classify them under 'living' and 'non-living'. However, it should be noted that they classify according to their experiences only. What are the characteristics of the living things ? How do they differ from the non-living ? Let us have some understanding of these characteristics.

Major Concepts

1. A living thing shows the characteristics of 'Life'. (It has a cellular organization, it metabolizes, grows and self perpetuates through a process of reproduction).
2. Plants and animals are living things but, at the same time, they show certain differences.
3. Plants and animals are interdependent and they together maintain the balance in nature.

Activities for the School

A Living Thing Shows Characteristics of Life

For an understanding of life you should try to discover various qualities that distinguish living things from lifeless objects. You may have little practical difficulty in differentiating living animals and plants from lifeless things. But you may remember that it is hard to find consistent and sharp distinction between them

You may recall all living and non-living things are made up of atoms and molecules.

But in the living things the complex molecules are organised in a special way in the form of very large molecules—proteins, carbohydrates, fats and nucleoprotein which are the basic forms of various life activities. These large molecules along with water, various salts and minerals, are organised in the form of small chambers-cells. Cell is the structural and functional unit of all living beings.

Can you name a living thing without a cellular organization ?

You may ask students to prepare slides of hydra, spirogyra, onion scales, etc. and to observe them clearly. The emphasis should be on the understanding of the cellular organization of the organisms You may also show them charts depicting the cellular organization in unicellular and multicellular organisms. (A detailed account of these has been given in the chapter "Cell Structure and Function" You are advised to refer to this chapter).

It may be mentioned that in a non-living thing the atoms and molecules are not organized into cellular units. At the same time it should be pointed out that crystals have a definite organization and have a perfectly organised molecular structure.

Why do you consider a crystal as a non-living thing in spite of its perfectly organized molecular structure ?

What is the living matter of the cell ?

Ask the students to observe the wooden chair, cork, dead leaves, etc.

Do they have a cellular structure ?
Do they have the living matter of the cell ?

In a multicellular organisms, the cells are of various shape, size, function and origin. Similar cells often aggregate together to form tissues You may tell the students that the organs in their body such as liver, heart, kindney and those of a plant body such as stem, leaf and root are all made up of various types of tissues. The organ performing similar functions combine and coordinate with each other in a definite way to form organ systems, for example, circulatory system, photosynthetic system, reproductive system, etc. The success of this type of organization lies in the efficient coordinations of different parts. You may note that these points can be taught by using beautifully illustrated charts and appropriate models.

Do you think such a cellular organization is evident in a non-living thing, say, a stone ?

Your students may be allowed to grow seeds on a wet filter paper or sawdust at different intervals of time and observe for some days.

Do they germinate ?
Do they grow ?

Let them also observe children of different ages and find out whether there is any relation in height and weight.

You can show them trees which are growing new branches. A chart showing the various stages in the development of the

human body from a single cell can also be used to explain the point that one of the most important features of living things is growth which is always accompanied by development (you may refer to the chapter "Growth and Development").

Let your students prepare a saturated solution of copper sulphate or alum in a beaker and hang a small crystal of the same in the solution and observe.

Does the crystal grow ?
Do you find any difference between the growth of a crystal and that of a human being ?

It should be pointed out that the growth of a sand dune or a crystal does not involve a chemical change and therefore reversible The growth in living things is irreversible and involves a chemical change.

You eat and drink a large variety of food materials. Why ? They provide basic building materials and energy for your body.

What does your food contain ?
Do plants take their food ?
How do they take ?
What is photosynthesis ?

Now let us see the food of non-living things They also consume food. But not for keeping their body 'alive'. Without food an engine will not die. The 'food' of a steam engine does not get assimilated into its body.

Let the students observe a candle flame.

Does it consume food to keep the flame alive ?

You eat food to get energy. The energy, necessary for all the activities, is obtained through a process called respiration. The food combines with oxygen and releases energy and carbon dioxide (you may refer to the chapter on "Respiration").

Such gaseous exchange is also found in certain non-living thing.

Can you give an example ?
Is there a gaseous exchange when a candle burns ?
Is there any energy release ?
What is the difference between combustion and respiration ?

You know that the roots of plants grow under the ground. They grow away from the source of light. If you look at the bright sun you close your eyes immediately. If you touch a very hot object you at once withdraw your fingers. Why ? These are all your responses. All living things respond to their environment. This responsiveness or irritability is an expression of the dynamic nature of the protoplasm. This stimulus-response reaction is always advantageous to the organism

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Do non-living things respond to stimuli ?
Is this response advantageous to them ?
What happens when a cardboard is placed in the sun ?
Can you give examples of internal stimuli to which man responds ?

It may be mentioned that each living organism has control systems which maintain normal internal conditions even when there are changes in the external and internal environments. This maintenance of normal conditions inside the body is a stable

characteristic of all living beings and is called homeostasis. This homeostatic control allows the organisms to receive information from the environment and to act. Thus the stimulus-response reactions help the organism maintain the body as such and to preserve it.

Carefully observe various responses of different organisms.

Another important characteristic of a living thing is that it self-perpetuates through a process of reproduction. You can give the example of a mango. The seed of the mango tree germinates and grows. It becomes mature and produces a large number of seeds again. They germinate to form new plants. Thus there is a cycle of well defined events in the life of a living thing.

Does a stone grow and reproduce young ones ?

The above point can be explained with the help of neat and clear charts The students can also be asked to trace the events in the life cycle of a plant or an animal. You may also use the local environment by taking a student as a teaching aid on one hand, and the chair, chalks, bag, etc. on the other hand. Ask the students to observe their behaviour etc. and record their observations.

A large number of chemical processes are going on in the cells of a living organism. These are called metabolic activities They are of two types : One, constructive, which includes the synthesis of food materials, and the other destructive, the breaking down process.

What are the constructive processes in a living organism ?
What are the destructive processes in a living organism.

These two types of processes keep the living things dynamic.

Assignments

1. Collect samples of living and non-living things
2. Prepare charts of living and non-living things.
3. Prepare a chart classifying things into living and non-living.
4. Demonstration of different organs may be done with dissected frog or rat.
5. Prepare charts and models showing the major types of tissues in plants and animals.
6 Prepare slides of tissues of different plants and animals.

Plants and Animals are Living Things and at the same time Show Differences

You are aware that the dog is an animal and a mango tree is a plant. What are the characteristics on the basis of which you classify them ?

You move from one place to another, may be with some definite purpose. Does a mango tree move ?

Why do you move from one place to another ?

A mango tree is fixed at one particular place. Locomotion or movement of the whole body of an organism is a characteristic of animals,

Do you know any animal fixed at a particular place ?
Do you know any plant with locomotion ?

The movement of a part of an organism may also be due to certain stimuli Such movements you can observe in plants You can ask your students to note down such movements.

The plants are autotrophs while the animals are heterotrophs.

How do plants and animals differ in their mode of nutrition ?

You may give the example of wheat grain. The wheat plant absorbs raw food material from the soil and CO_2 from the atmosphere and convert them into organic molecules utilizing solar energy with the help of chlorophyll. These organic molecules are stored in the grain which we use as our food. You may emphasise that plants contain chlorophyll which can be reinforced by chlorophyll extraction experiment.

What is chlorophyll ?

As you have already noted, plant and animal bodies are made up of cells, tissues, organs and organ systems. But the level of complexity is more in animals, because various organ systems are well developed in them

Give the names of the various organ systems in man

Another difference is that the plant cell has a cell wall which the animal cell does not have. (You may refer to the chapter on "Cell Structure and Function").

There is also a difference in growth (see the chapter "Growth and Development"). Let the students try to find out the differences in their structures and forms.

Is growth in plant unlimited ?

Assignments

1. Prepare a chart showing common plants and animals.
2. Prepare a chart showing the differences between plants and animals.

Plants and Animals are Interdependent and they together Maintain the Balance in Nature.

(*a*) Plants produce their own organic food. Therefore, they are called "producers".
(*b*) They absorb CO_2 and give out oxygen essential for animals.
(*c*) Animals are called 'consumers' because they consume the food produced by the plants.
(*d*) The dead plants and animals are decomposed by bacteria and other micro-organisms. They are called 'decomposers'.
(*e*) The producers, consumers and decomposers co-exist in nature.

Methods Used

In teaching this topic various methods have been used. First of all the students are asked to recall what they learnt in their previous classes. Then the teacher explains some theoretical concepts which are followed by students' activities. While assigning activities, you may be required to make a lot of preparation beforehand. The activities should be well-planned. Activity can

be prescribed as individual activity or group activity. These activities depend upon the quantity of materials available in the laboratory. If the materials are not enough then you may demonstrate the activity. Demonstrations are done on a raised platform so that all the students may be able to see them. During the activities, the students observe, collect and analyse data, and draw conclusions about the relationship between the living and the non-living. Their observations are further strengthened by putting some relevant questions. Where activities are not possible, some charts have been used as a teaching aid to make the teaching effective. The quality of charts should be judged by the teachers. The chart should be hung at such a distance that all the students may be able to see easily and read themselves. If charts are not available, then the teacher may draw diagrams on the blackboard. In this topic the student himself, since he is a living being, is also used as a teaching aid. He is compared with the non-living.

Assessments

1. What in your opinion is the most distinct feature that helps in differentiating a living thing from a non-living thing ?
2. A stone is said to be non-living Why ?
3. Can you name a few stimuli and responses in man ?
4. Prepare a lesson plan to distinguish between :
   Autotrophs and Heterotrophs,
   Combustion and Respiration,
   Locomotion and Movement,
   Excretion and Secretion
5. What are the differences between the growth of animals and plants ?
6. Prepare a chart showing the interdependence of plants and animals.

REFERENCES

1. Weisz, P B., '*The Science of Zoology*', McGraw Hill, Inc , New York, 1966.
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CHAPTER 5

Cell Structure and Function

Introduction

One of the ways of introducing this topic could be to start with a discussion of the differences between the living and the non-living and between plants and animals. After making a brief mention of these points you may tell the students that in spite of the differences, plants and animals exhibit a fundamental similarity, that is, they are made up of structural units called cells. A brief account of the significance of the discovery of cells in a piece of cork by Robert Hook in 1665, using one of the first microscopes, can be mentioned here. It would be apt to tell the pupils that this discovery was the real starting point in an organised study of living beings, and that our present-day knowledge pertaining to cells is largely due to the work of generations of scientists using new and more sophisticated instruments and laboratory techniques. Specific references with regard to the new tools such as electron microscopes, phase-contrast microscopes, ultra-centrifuge, etc., have to be made, because these have now been employed to look into the exceedingly complex structure of the cells.

Major Concepts

1. All living beings are made up of cells.
2. Organisms may be unicellular or multicellular.
3. The plant cell has a rigid cellulose cell wall.
4. The cell contains a large number of organelles and particles of exceedingly complex composition.
5. All cells arise from the pre existing cells (division or union)

Activities for the School

All Living Things are Made Up of Cells.

It may not be desirable to have a detail-

ed discussion on the historical background of the various theories and concepts on cells. However, it should be emphasised that the idea that the cells are unit structures in plants and animals was first suggested by a German botanist M J. Schleiden (1838) and a German zoologist, Theodor Schwann (1839). The concept that the plants and animals are composed of cells can be explained by carefully giving some activities to the pupils, or you may demonstrate or discuss with the help of charts and models.

You may ask your pupils to take an onion peel and observe it under the microscope Ask them to sketch what they see. Let them make a note of their observations.

Can you see certain small cabins ?
What are those cabins ?
How many such cabins are present in a small piece of onion peel ?
Do you see anything other than simple cabins ?
Can you make out the size and shape of the cabins ?

They may also be asked to scrape carefully the inside of their cheeks using the blunt end of a clean scalpel and mount this for microscopic examination. Let them sketch and compare this with the drawings of the onion peeling.

Is there any difference between plant cells and animal cells ?

In these activities the emphasis has to be on keen observation of various kinds of specimens. Pupils can be asked to perform more activities like the observation of filamentous specimens of algae, especially *spirogyra* collected from a nearby pond or a lake However, the classical experiment by Robert Hook can also be repeated. But before performing this experiment, pupils must be told that they are repeating what Robert Hook did which enabled him to coin the word "cell". They can be told that similar microscopic studies reveal fundamentally the same architectural plan, namely, cell, as the basic unit structure in plants and animals.

Assignments

1. Copy from the book the original description of the cell as given by Robert Hook.
2. Collect photographs of various types of cells.
3. Find out the differences in size (using unit of microscopic measurement) and shape of cells.
4. Make a list of some cells which can be seen with the naked eye.
5. Make charts depicting various types of cells.
6. Make the model of a cell of the specimen which you have observed.

Organisms May Be Unicellular or Multicellular.

From the previous activities pupils will obviously conclude that the organisms are made up of cells. They will also be able to identify cells. Now you may tell them about the existence of organisms whose bodies are made up of a single cell (unicellular) or a large number of cells (multicellular) It may be mentioned here that in the unicellular ones, the cell and the organism are one and the same, while in multicellular ones, there is an integration of cells for a proper functioning of the body. The pupils may be asked to recall the examination of

the onion peel and the filament of Spirogyra.

What makes you conclude that onion and Spirogyra are multicellular organisms ?

Ask them to observe thin sections of a young root or stem of a plant and note their observations. Also, ask them to collect some water by squeezing the submerged water plants and observe a drop of it It is possible that such a collection contains a large number of unicellular and multicellular plants and animals A reference has to be made to the common ones like Euglena, Colpidium, Closterium, Diatoms, Oscillatoria, Spirogyra, Zygnema, Amoeba, Paramoecium, etc. Let them identify and group them accordingly. Ask them to maintain a record of their observations along with neat diagrams.

Observe the common unicellular and multicellular organisms present in a nearby pond or a lake How many of them are plants and how many are animals ?

While examining the specimens they may come across some colonial forms like Volvox, Pandorina, etc These are composed of numerous cells associated intimately in the form of clusters.

Do you think all the cells are alike in size and shape ?
What structural differences do you observe ?

Good charts/models depicting various types of cells like nerve cells, muscle cells, etc. can also be shown.

Assignments

1. Collect pond water and observe living algae and protozoa. Identify and classify them.
2. Draw neat and labelled diagrams of the common unicellular and multicellular organisms.
3. Group the common plants and animals into unicellular and multicellular.

The Plant Cell has a Rigid Cellulose Cell Wall.

Every cell has a cell membrane, the plasma membrane, which functions as a protective layer in addition to regulating the flow of substances. It allows the flow of certain substances only. Therefore, the plasma membrane is called a selectively permeable membrane. It is a biological membrane which also functions as a reactive surface. What are these biological membranes or bio-membranes made up of ? They are made of lipids and proteins In some, carbohydrates also occur. An experiment of carrot osmo-meter may be performed. This may also be given as an individual activity.

While observing the various cells in the previous activities the pupils might have come across an outer layer of the cell. This rigid layer or cell wall as it is called is external to the plasma membrane. The rigidity of the cell wall makes it a protective layer. To a certain extent it determines the shape of the cell also. In addition to cellulose, the cell wall is composed of large number of chemical substances manufactured and secreted by the protoplasm The physical properties of the cell wall are largely due to the cellulose. It will not dissolve in water, but it will absorb water in large quantities and allow it to pass freely in and out of protoplasm. The cell wall may also contain lignin, cutin, suberin, small quantities of minerals and other

materials. Cutin and suberin are waxy materials and are deposited extensively on and in the walls of cork and other types of cells

Do these substances make the cell wall permeable to water ?

Lignin is an organic substance found in the cell walls of wood. In many kinds of cells, particularly in wood, the walls of most cells are not uniformly continuous. Some minute thin areas are left out in the cell walls.

What are these thin areas called ?
How do they help the plants ?

Some types of cells have very small pores through which strands of protoplasm called plasmodesmata extend from the protoplasm of one cell to that of another. These protoplasmic connections help in the interchange of foods and other materials from cell to cell

Plasma membrane is an active part of the cell which controls the inflow and outflow of substances in a cell and, therefore, it is called a selectively permeable membrane. Plants have a rigid cell wall external to the plasma membrane.

Assignments

1 Find out from the books how plasma membrane is useful to the organisms in their life processes.
2. Set up and describe an experiment using any semipermeable membrane to show that it allows the flow of certain substances only. You may refer to the books also.

The Cell Contains a Large Number of Organelles or Particles of Exceedingly Complex Composition.

Now that the pupils are aware of the binding membrane, with the help of charts/models/filmstrip/film, etc they can be told that internal to the cell wall there is the protoplasm which is distinguishable as

i. Cytoplasm, which is a viscous, transluscent, jelly-like substance, filling up almost the whole of the interior of the cell

ii. The nucleus, a comparatively dense, prominent round or oval body, almost at the centre of the cell.

What does the protoplasm contain ? It contains cell organelles apart from other inclusions which are products of metabolism, like sugars, fat globules, starch, glycogen, secretions as well as many other organic and inorganic materials. Some of the organelles are active sites of the vital functions of the cell

As you know, the nucleus is the centre which directs the important activities of the cell such as synthesis, digestion and assimilation of food, formation of the cell wall, cell division, growth and transmission of hereditary traits to the offspring in reproduction.

What would happen to a living cell if its nucleus is removed ?

Ask the pupils to make microscopic preparation of a slide of a root tip and observe. Let them look for a cell which has an intact nucleus and is not dividing. They should be informed that the same activity can be performed to identify the various stages of mitosis at a later stage. After locating a cell with a clearly stained nucleus they may be asked to identify the

various parts. The nuclear membrane which delimits the nuclear contents from the rest of the protoplasm is a thin membrane One important point to be remembered is that the nuclear membrane is a double walled structure with a large number of pores present in them and may be continuous with the endoplasmic reticulum. Nuclear sap is the liquid material present in the nucleus. It is rich in protein. The nucleolus appears as a spherical refractive body bathed in the nuclear sap It plays an important role in protein synthesis. It is also involved in RNA metabolism. Another component of the nucleus is the chromatin which occurs in the form of a diffused irregular network. This is visible only when the nucleus is suitably stained. It should be pointed out to the pupils that the chromatin reticulum has two distinct regions : one, which is densely stained, and the other which is lightly stained. The former is called heterochromatin and the latter euchromatin Further, they have to be told that it is this chromatin that becomes what are called chromosomes during cell division and that the chromosomes are made up of proteins and DNA. They also contain some RNA.

Why do offsprings resemble their parents ?

It is to be noted that character is transmitted from the parents to their offspring through chromosomes. These hereditary characteristics are controlled by small units in chromosomes called genes. Each gene or a group of genes is responsible for a particular character and has a definite location in a chromosome. You can point out to the students that there is a particular gene for blue eyes, one for brown eyes, one for curly hair, one for straight hair and so on There are thousands of genes in an organism. These are distributed in the chromosomes. During cell division, when the chromosome splits into two equal halves, the genes also divide equally. Therefore, the daughter cells will have the same number of genes as those of the parent cell.

What is the difference between a chromosome and a chromatid ?

The cytoplasmic organelles are the endoplasmic reticulum, ribosomes, golgi complex, mitochondria, centrioles, lysosomes, vacuoles, nucleus, etc. In addition to these, plant cells contain plastids but they lack centrioles Ask the students to locate the cell organelles in the charts.

Endoplasmic reticulum is a network of membrane bound canals extending throughout the cytoplasm There are two types of endoplasmic reticulum, one rough surfaced and the other smooth. The rough surface is because of the presence of minute particles called ribosomes. Some of the membranes of the endoplasmic reticulum open in the plasma membrane. The rough surfaced endoplasmic reticulum is actively engaged in protein synthesis The endoplasmic reticulum probably plays an important part in the transport of materials through the cytoplasm It also helps in organising chemical reactions within the cells

We have already noted that ribosomes are very small particles. They may be present in the endoplasmic reticulum also. But they are also found dispersed in the cytoplasm singly or in groups They contain RNA and protein and are concerned with the synthesis of protein.

Another cytoplasmic organelle is golgi complex which consists of a stack of membrane-bound cisternae. These cisternae are arranged in straight or curved bundles and give rise to small vesicles at their edges. It is commonly found in the secretory cells of animals like liver or pancreas and sometimes in the meristematic cells of certain plants They may be concerned with the formation and storage of special compounds secreted by cells

Mitochondria are very small and vary in their size, shape and number in different cells. They are bound by a double membrane, the inner one folded inwards to form finger-like processes called cristae. Mitochondria contain a large number of enzymes which participate in respiratory reactions, resulting in the release of energy. This energy is stored in the form of a high energy chemical bond called Adenosine triphosphate or ATP. The Mitochondrion is, therefore, appropriately called the 'power house' of the cell

In the plant cells, there are a large number of small bodies associated with the metabolic progresses called plastids These are of three types : chloroplasts, chromoplasts, leucoplasts. Chloroplasts are green in colour because of the presence of chlorophyll which traps energy from the sun to be utilised during photosynthesis. Chloroplast is also bound by a double membrane. Internal to the membrane, there are two distinct regions, the grana and the stroma. In the chloroplast, the chlorophyll molecules are arranged in between the alternating layers of proteins and lipids and these layers are arranged like a stack referred to as grana. The ground substance is stroma.

Leucoplasts are nonpigmented round bodies found in the meristomatic cells and in storage cells, while chromoplasts contain various types of pigments other than chlorophyll. The red colour of ripe tomatoes is due to the presence of chromoplasts

Lysosomes are minute spherical sacs which are said to contain specific hydrolytic enzymes that digest cellular substrate, etc. Lysosomes help in removing the undigested and unwanted particles from the cell. These are also called "suicide bags" because when their walls rupture, the enzymes released may digest cell components and the cell itself

Centriole is characteristic of animal cells. It has a critical function in cell division as it determines the axis of division

In addition to the above mentioned organelles, plant and animal cells contain fluid-filled spaces called the vacuoles. Each vacuole is bound by a membrane, the tonoplast The cell sap of a vacuole contains mostly water in which various substances are dissolved.

So far, we have seen the structures associated with the basic functions of the cells. It should be noted that most of these organelles cannot be seen with an ordinary microscope and therefore appropriate teaching aids have to be used These may be charts or models, or film/filmstrip, etc.

Make a list of the organelles which are present in plant cells.

All Cells Arise by the Division of the Pre-existing Cells and Cell Division Carefully Planned and Timed Even in the Type of a Cell

We have seen that a seedling grows into an adult plant. Likewise, a baby into an adult. Growth takes place both in living and non-living beings. The process of growth in both of them is different. Growth

in the non-living world is simply due to addition or deposition of substances Growth in the living world depends upon the conversion of the outer materials, such as food inside the body. The food is assimilated in the body to produce body substances. If you soak a seed in water, the size of seed is increased—will you call it a growth? The growth and development of all living organisms depend on the growth and multiplication of the cells In the unicellular organisms, division of the cell may lead to multiplication which is a form of reproduction The body of higher organisms also originate from a single cell, called the zygote The repeated multiplication of this cell develops into an individual There are two important types of cell divisions. (*i*) Mitosis, and (*ii*) Meiosis.

(*i*) *Mitosis*: Mitosis is a type of cell division in which two cells are formed from one cell It involves the division of the nucleus and the cytoplasm. You may first demonstrate this concept with the help of models/charts The production of two cells by mitosis is the climax of a series of events. These can be explained with the help of students' activities. Distribute the bits of onion root tips to the students Ask them to stain in acetocarmin. Let them heat gently. Put a cover slip. Press it carefully. Observe under the high power of the microscope. Ask the students to observe and draw different stages of cell division. Just before the cell division, the nucleus of cell prepares for division and is called the interphase nucleus. There are five stages in the cell division and these are prophase, metaphase, anaphase, telophase and cytokinesis. The pupils have to be told that all the stages of cell division are part of a dynamic process.

Why do we select onion root tips to teach mitosis?

What is the significance of mitosis? It may be narrated that it is a means of reproduction in the unicellular organisms. In the multicellular ones it helps in the growth and development of the organisms. It is known that the genes are arranged longitudinally on the chromosomes, and when chromosomes split longitudinally into two, the genes also divide equally into two. This means that the two chromatids get again the equal number of genes.

(*ii*) *Meiosis* While mitosis occurs in the vegetative body of the organisms, meiosis occurs in the reproductive organs only. Here in place of onion-root tips you may take pollen grains Follow the same procedure as followed in preparing the slide of onion root tip. After this you may narrate with the help of charts/models that in the sexual reproduction there is the fusion of the egg and the sperm, the former from the female parent and the latter from the male parent. The reproductive cells first undergo a reduction division (first meiotic division) and then mitotic division (second meiotic division) In the reduction division not one chromatid but one chromosome (two chromatids) is separated from its corresponding pair. Thus two cells are formed, each with half the number of chromosomes These two daughter cells undergo mitosis and result in the formation of four daughter cells with only half the number of chromosomes. This process is also completed in various stages such as prophase, metaphase, anaphase and telophase. During reproduction, the male cell and the female cell, each with half the number of chromosomes, force to form a zygote with the original

number of chromosomes. Another important event during meiosis is the exchange of genes between the pairs of chromosomes Such changes in the genes cause variations within a species

Meiosis requires longer duration to be completed It produces four daughter cells and reduces the number of chromosomes and also causes variations.

How does meiosis differ from mitosis ?

Assignments

1. Preparation of suitable slides for the observation of various stages in mitosis and meiosis.
2. Preparation of charts and models depicting various stages of cell division.
3. Make a model of cell showing all the parts
4. Make charts showing the structure of cells.

Methods Used

This topic is very difficult to teach if we think of teaching it by using only one method. Here a cluster of methods has been used. Students may be motivated by teaching in brief the historical aspect by describing how our scientists strive hard to gather knowledge of cells. Later on, the concepts are strengthened by giving students activities or demonstrations by the teacher (for further details refer to Chapter 4) Use of charts, models, diagrams on the blackboard, film, filmstrip, etc. have also been used. The teacher is required to narrate various functions of cell and cell organelles. While teaching cell division, you should be very careful in selecting material for the activity, and preparation should be made beforehand. To develop psycho-motor skill in the students you should ask the students to draw diagrams in their notebooks

Assessments

1. The chief component of the plant cell wall is
   (*a*) fat
   (*b*) cutin
   (*c*) cellulose.
2. An animal cell has no
   (*a*) cellulose cell-wall
   (*b*) mitochondria
   (*c*) centrioles.
3. Mitochondria are called the power house of the cell because
   (*a*) they are actively participating in cell functions,
   (*b*) they store ATP during respiration,
   (*c*) they help in photosynthesis.
4. Chloroplasts are the active sites of
   (*a*) fat synthesis
   (*b*) photosynthesis
   (*c*) respiration.
5. Draw neat and labelled diagram of a plant cell bringing out all the structures as seen under an electron microscope.
6. Distinguish between
   (*a*) Mitosis and Meiosis,
   (*b*) Tonoplast and Cell Membrane;
   (*c*) Chloroplasts and Chromoplasts.
7. Give a brief account of the cytoplasmic organelles and their functions.

CHAPTER 6

Ecosystem

Introduction

Ecosystem is the basic functional unit in ecology It includes both organisms and their non-living environment, each influencing the properties of the other and both are necessary for the maintenance of life The term 'ecosystem' was first proposed by the British ecologist A.G. Tansley in 1935 The Russian and some German ecologists still use the terms such as 'biocenosis', 'geobiocenosis' for an ecosystem. The concept of the ecosystem is a broad one and its main function in ecological thought is to emphasize the relationships and interdependence between organisms and their environment.

The ecosystem, when taught in schools, should reflect this fundamental and functional unity and bring out the generalization of interrelationships The teaching of ecology in general and ecosystem in particular fails to achieve its main objectives because the area is new to many teachers and its teaching, even at the college and university levels, is still theory-dominated rather than having a balanced theoretical-practical approach

The generalizations and conclusions of ecosystems have been based on the studies of animals, plants and their environment and their interactions spread over long periods of time carried out in different parts of the world When an ecosystem is analysed at any particular time, all the unities of it and the dynamics of factors operating on it may not be quite evident The ecosystem needs to be analysed repeatedly to understand it fully. These limitations need to be kept in mind while teaching ecosystem and ecology The teaching of this subject can be made more lively, interesting and stimulating through certain selected activities

Major Concepts

1 An ecosystem is the totality of the living and the non-living constituents of a functional unit

2 The ecosystems range from a vast natural one like an ocean to a small man-made one like an aquarium

3 The four fundamental components of an ecosystem are the abiotic factors, producers, consumers and decomposers.

4 The aquatic ecosystems include seas, estuaries, rivers, lakes, streams, ponds, marshes and reservoirs

5 The terrestrial ecosystems include forests, deserts and grasslands.

6. Natural ecological groupings of plants and animals extending over large areas are the biomes.

7. Physico-chemical conditions such as rainfall, temperature, composition of soil and barriers such as mountains, seas and deserts, determine the nature and extent of of a biome.

8. The variations in physical features like rainfall, sunlight, altitude and duration, growth, season of plants, have given rise to different kinds of biomes.

9. Tropical evergreen forest is a biome, in which rainfal is high and uniform with no dry season, with a rich fauna and flora.

10. Tropical deciduous forest is a biome with a dry and wet season. Fauna and flora are less dense than the tropical forest

11. Temperate deciduous forest is a biome in the temperate belt with well-defined summer and winter and well-spaced and fairly abundant rainfall

12. Taiga occurring in the northern hemisphere is marked by long and severe winter with a mild summer and very short growing season affecting the life of animals to migrate or hibernate periodically.

13 Grassland biome with intermittent rainfall is dominated by grasses with a rich variety of game animals.

14 Desert biome with scanty rainfall and extremely high temperature shows poor flora and fauna showing extreme adaptations for water conservation

15. The Tundra biome with a frozen environment during most of the year shows absence of amphibians and reptiles, but flora of lower plants are present

16 The polar biome with a permanently frozen environment is without flora but with scanty fauna which depends upon the adjoining oceanic ecosystem

Activities for the School

1 By showing your pupils an aquarium and a chart of the profile of a pond you may help them discuss the points of similarities between a pond and an aquarium. Blackboard could be used to record the points of similarities.

The pupils may be helped to recall their previous knowledge with regard to the concept of 'species' and 'populations'. It is necessary to bring clarity in the minds of children regarding the differences between species and population, and community and ecosystem

It is well known that some zoos have succeeded in cross-breeding of a tiger and a lion. Does this contradict the definition of a species "as a group of similar individuals that interbreed" ? Will you, as a teacher, accept that a lion and a tiger belong to the same species ? How will you bring clarity in the concept of a species ?

2. *Field Trip to a Pond*: How can the concept be cleared that an ecosystem is

made up of two basic components ? One way, which many teachers follow, is by telling or discussing with the pupils that a pond ecosystem, for example, has (1) abiotic features, (2) producers, (3) consumers, and (4) decomposers. It is a very easy method and the teachers' work is made very light. But the investigations carried by research workers have revealed that such a method does not create effective teaching-learning situations.

What is the alternative teaching strategy ? You might take your pupils for an excursion to a nearby pond. If you do so, you can see for yourself, how excited the pupils become. Field trips always require prior planning. Why ? You can save time and you can make it as an effective tool of learning. In this particular instance you might select a suitable pond out of a few that are available around your school. You should keep the purpose of your field trip as your focal point To achieve this aim, you should provide the necessary instructions for what the pupils should do Impart instructions through a series of stimulating questions so that your instructions become more meaningful for them. How can you maintain discipline while the pupils are on their field trips ? What work can you entrust to your pupil leaders ? Keep a constant vigil on your pupils. On the way to the pond there might be an unused and unprotected well. Your pupils might be inquisitive to peep into it pushing one against the other. Such a playful attitude might result in your pupils' falling into the well and hence you should take necessary precautions and maintain discipline.

What is the purpose of your field trip ? Collect some samples from the pond and keep the collection in a bottle. Help your children to label the bottle. You might incidentally ask them the need for labelling such collections Samples of water plants might be obtained. Using nets they might collect organisms found in water. Pupils might scoop out pond soil and collect them in a bucket After your return to the school the anticipated objectives are fulfilled.

3. *Pond Ecosystem Analysis* ; Laboratory work . Analysis of the collected samples can be done for different purposes. Immediately you might be interested in analysing them into the four components of an ecosystem. For identifying some of the organisms a microscope may be needed Your pupils may not be familiar with most of the organisms collected from the pond You should never be over ambitious to teach them how to identify all the organisms. Proceed slowly Acquaint them with a few at a time If you are not able to identify many of the organisms present in your sample what will you do ? No teacher can be sure of identifying all the organisms present in a pond. But you can learn about it in course of time.

4. *Key to Identification of Pond Organisms* : Make your own plan which you consider will be convenient for you to learn to identify the organisms. What reference books will you follow for the identification of fresh water organisms ?

Select a few most common forms of producers and consumers and discuss. Show them decaying plants and putrefying small animals like insects, and discuss the role of decomposing organisms that are too small to be seen even with the help of microscopes Discuss the soil and its composition, similarly, the pond water and its composition. Ask your pupils to mention a few physical factors such as light, wind, rainfall, etc.

What kind of assignment given to the pupils after a field trip would help them realise its objective fully ?

5. *Comparison of Tables of Data* : Prepare a tabular statement that shows the comparison of the composition of sea water with that of pond water Where from will you obtain the data for the above ? You may consult any book on marine biology, oceanography and limnology. Discuss with the students the major points of difference between the chemical substances and properties of sea water with those of pond water Recall their familiar experience of the taste of sea water. Discuss the major differences between a sea and a pond in respect of their physical features such as water current, light penetration, wind, etc.

Do you know what is meant by upwelling in sea ? What is its significance ?

6. *Marine Ecosystem—Study of Zones from Chart* ·

Help the students draw the profile of sea showing its major zones or show them a good chart and discuss the following (visit the sea shore if accessible nearby) :

(*a*) Continental Shelf : What is it ? For what distance does it extend from the sea ?

(*b*) What would be the pressure of the sea water at different depths ? Give some interesting data What would happen to land animals if taken there and left unprotected ? This might help them to appreciate the adaptation of sea animals for withstanding the enormous pressure.

(*c*) What are the types of producers found in the 'near shore' region and how are they different in offshore regions ?

(*d*) The use of sea weeds.

(*e*) Is whale a fish ? If not, why ?

Help them collect information on underwater explorations and prepare either a children's book or an article with points of underwater exploratory vessels. Also display most interesting accounts and experiences on the bulletin board, or for circulation among those interested in reading them.

7. *Collection of Soil Samples*

You may help pupils select the soil at the base of a garden plant Why should we select the base of a garden plant ? Because it has been watered daily and contains sufficient litter at the surface and hence it is ideal for the breeding of soil organisms. You may select an area and help pupils dig up to about 40 cm depth. The exposed area may be divided into four vertical zones, each of about 10 cm in thickness Help them take samples of soil after quickly measuring and recording the temperatures of different layers. Let the samples be brought to the laboratory in polythene bags.

In the laboratory, ask the pupils to take a spoonful of the soil sample in a test tube and mix it thoroughly with an equal quantity of barium sulphate in 20 ml of distilled water. Allow it to stand for a few minutes Let a pupil pour a small quantity of the supernatant into a test tube and add an equal quantity of the pH indicator. Help the pupil match the resulting colour with the standard colour of the chart and record the values.

You may help the pupils make a paper cone and fit it in a tea filter or wire netting over the broad end Let the cone be fixed to a stand and a glass tumbler containing a little formalin underneath. Suspend a 40 watt lamp to about 20 cm above the cone. Let them spread the soil sample in the filter above the cone After the light is switched on, leave the set-up undisturbed for 12 hours

What do you expect ? The arthropods and other organisms affected by the heat and light are passed through the sieve and fall into the tumbler which can be collected and counted Let the activity be repeated separately for the different samples Help them compare the results and draw conclusions about the vertical distribution of organism in the soil

8 *Study Biomes through Games*

Encourage your pupils to collect pictures of animals from magazines and landscapes of different types Help them prepare graphs of annual rainfall, temperature ranges, etc. Ask them to match the flora, fauna, and the physico-chemical features of different biomes.

Exhibit them in the class Let other pupils visit the exhibition and discuss in the class.

Method Used

In teaching the topic of ecosystem an aquarium has been used in place of pond This may be done if in any locality a pond is not available nearby. Conducting field trips is of immense importance. This gives first hand information to the learners While organising field trips you should plan properly, keeping in view the objectives of such trips. Details regarding this are clearly given in the text During the field trip, students collect materials either from water or from land. They analyse and make their own key of identification The teacher may help them to conclude. Where sea water is not available the teacher has been advised to use tabular statements and charts. Activity method has also been used for teaching about collections of soil samples. Students will do this themselves. In this activity the teacher's guidance is needed very much. Teaching of different biomes may be done by narration or by using diagrams in the book Students are asked to collect pictures of animals/plants, etc. from magazines. They will enjoy this and will learn while playing.

Assignments

1. Examine collections of plankton, both marine and fresh water ones, separately From different collections of the same category (e.g marine), sort out the most frequently occurring planktonic organisms. Sketch the figures in a chart. If you are good in painting then you may do so. Place in them their respective broad categories, such as copepods, chaetognaths, nanplium larva, zoaea larva, etc. Similarly, you may identify the fresh water zooplanktonic and phytoplanktonic forms. If you are further interested, you may proceed to identify them to the generic level which is neither required for school teaching nor easy to identify

Consult standard textbooks in marine biology, oceanography and limnology for the keys for identification

How is this exercise going to be useful to you ? In the colleges of education and in neighbourhood there might be institutions where such reference books would be available, and staff members might also help you in your effort In the schools you may not get such facilities. If you do this

exercise, it might be of great use to you during your whole career as a teacher. You may prepare and keep with you your own simpler keys for identification.

2. Collect water samples of known volume from pond or sea, or from both sources separately. Filter them through blotting paper, or silk or organdy cloth Preserve them in 4·5 per cent formalin and bring them to the laboratory where you may count the number of each category such as cladocerams, copepods, etc. and draw histograms

If you have too many organisms in a sample, you may count all the organisms or a few. Shake the sample so that the organisms are distributed evenly. Take samples and count. If necessary you may take sub-samples of samples.

When you count the organisms under the microscope, how can you avoid counting the same specimens twice or more ? You may use counting chambers or improvise a suitable chamber.

Experience gained in this direction can greatly help you to encourage your pupils during your career as a teacher to take up such projects in science. The expertise and necessary skills can be developed in the college of education.

3 If you are given a collection of fish the feeding habits of which you do not know, how will you proceed to determine their feeding habits ? You may consult the methods of studying the feeding fostihab fish from any of the standard journals like the *Indian Journal of Fisheries*.

This exercise is an example of investigation in which you would come to conclusions on the basis of indirect evidences. By receiving such a training you would be able to design such activities for your pupils when you become a teacher.

4. Select any three different types of soils that are likely to show differences in pH What kinds of soils are likely to show such differences ?

Soil from a well-manured garden may provide a pH value lower than 4 5 Alkaline soil may be prepared in a corner of the garden of your school by the application of lime or ammonium sulphate.

You may place a quantity of each soil in a pot and make sure that the feature is loose Moisten with water and record the pH

Place an equal number of worms, say, 5, on the surface of each sample of soil. Cover them with glass. The air will enter through the porous walls of the pot. After a few days record the number of worms still remaining on the surface of the soil. Note whether they are dead or alive. So strong is the reaction against acidity that the animals may fail to burrow and remain on the surface until they die.

For which concept in ecosystem this activity would be suitable ? How can you make use of this activity both as an illustrative and as an investigatory type of experiment in teaching science at school ?

CHAPTER 7

Photosynthesis

Introduction

Food is very essential for all of us. What changes occur in a person if he does not take food for a few days ? You know without food no living being can survive for long. Plants need food for performing life processes which we cannot see. Animals generally use prepared food but plants make their own food from raw materials like CO_2 and water obtained from the environment. "If there are no plants there may be no life" Why ? How can you teach your students the significance of photosynthesis to our world ecosystem ?

Activities for the School

You can introduce your topic with some activity that motivates them or relates to their previous knowledge. You can also take them to the field and let them observe. Alternatively, you can proceed historically as the process of photosynthesis was discovered Here, you can pose the question.

Does all vegetable matter come from water alone ?

Ask your pupils to grow plants (may be a different plant for each group) in a couple of pots. Make one set as a control and the other as experimental. Don't water the experimental set of pots Help the students conduct experiments themselves Let them also conclude themselves. It is a good way of teaching biology.

What do they observe after 5 days, 10 days, 15 days ? Can the plants live without water ? Help the students make observations with different plants and at various intervals. Let them compare their results and list differences What reasons do they assign for these changes ?

This 'activity' may take a longer time. An alternate method to introduce the topic is the enquiry method.

Narrate the experiment of Van Helmont,

a Dutch Scientist in the 17th century, who performed an experiment to find out from where the vegetable matter of the plant came. He took a pot with 200 lbs of dried earth, planted a plant weighing 5 lbs. Fed the earth with rain water or distilled water. The earth was fully protected with a polythene bag After 3 years the plant and the earth were weighed. The weight of the plant was 170 lbs. But there was negligible (—2 oz) change in the weight of the earth. Ask the pupils such questions · Was Helmont correct or partly correct in his observations ? How do you think the increase in weight could be accounted for ?

What other things plants require to grow ? Would you conclude from the above that water is essential for photosynthesis or that water is essential for growth ? Now you can proceed further taking each concept step by step (see outline at the end of the unit)

Light Stimulates the Process

Group your pupils and ask each group to keep a few potted plants in the dark for 24 hours before the class. In the laboratory help the pupils to find out the differences in the plants kept in light and dark. Ask them to decolorise the leaves from both plants. Stain the leaves with IKI solution (consult appendix or Johnson's book on Microtechniques for the methods) for starch. Let them note the differences.

Can light bring about chemical reactions ?

You can prepare $AgNO_3$ (silver nitrate) solution, pour it in a petridish Ask your students to cover half portion of the petridish with a carbon paper to check light and expose the rest to light. The exposed portion turns black Light has stimulated a reaction Similarly, in photosynthesis light stimulates a reaction.

For You to Do

1. Try the same experiment with different plants which were kept in dark for a period of more or less 24 hours Observe the differences. Perform the experiments with lower plants and water plants also. Discuss how the use of lower plants may be useful for teaching.

Are photosynthetic phenomena common to land and aquatic plants ?
See if you can find from books whether land plants trap more solar energy than acquatic plants

You may like to know that the average utilisation of solar energy by plants on land is not more than 1% This proportion is raised to about 2% if only the visible light absorbed by the plant pigments is taken into account.

2. Devise experiments in which you

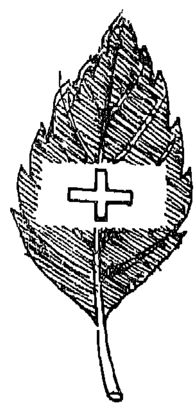

Fig. 7,1 Experiment showing that light is necessary for photosynthesis.

may cover a portion of the leaf where no light falls (Fig. 7 1) Some times aluminium light screens are available in the laboratory or you may improvise them also.

How do indoor plants obtain light ?

3. You know radiations are of various wavelengths. The visible light $(400^{\circ A}-700^{\circ A})$, is used by the plants for photosynthesis. Which wavelength is most suitable ? Plan a *project* for your pupils utilising transparent papers of different colours. What colours enhanced the rate of photosynthesis ? How will you measure the relative rate ? Discuss with your students the possible errors in such experiments. How much time will this project take ? Write an outline of the project and show it to your teacher.
4. What are green houses ? Do you have any in the school or in the college ? Make a blueprint and estimate the cost of one greenhouse (may be an improvised one), for a school in your locality. List the plants you will like to grow.
5. Discuss in your class what does the term 'Photosynthesis' mean ? What relevance does it have to the process ? Would you like to give some other terminology for the process we are discussing ? This term was coined in 1898

Pigment and Site of Photosynthesis

It is important for your pupils to know the site where exactly photosynthesis takes place. Which organs, tissues, cells and cell organelle are really involved ?

Link the earlier concepts by asking the following questions : Why do we take only leaves for the study of photosynthesis ? Why not roots or other parts of the plants ? What would happen if you select a plant which may not have any leaves (in desert areas there are a number of them) or lower plants which may be leafless or thalloid ? Do you mean the plant would die if we remove all of its leaves ?

Help your pupils collect some algae, if available nearby, or let them take peels of some ferns or they may select any leaf of a plant Let them prepare microscopic preparation which is stained with iodine solution or IKI solution. If available in your school, put the ocular scale in the eye piece and help them in measuring the size of the chloroplasts. Ask the students to make a table (on the following lines), collect data from all students and record it in a common table.

Observational Chart

Name of the Plant	*Area Collected*	*No of Chloroplasts*	*Size of Each Chloroplast*	*Remarks (deep/light stain) or Shape of Chloroplast*

For You to Do

1 Study blue green algae (oscillatoria, anabaena for instance) Do the cells have chloroplasts ? If so, how do they manufacture their food ?

What are prokaryotic cells ?
Search for some examples of this category.

2 Make a chart of a chlorophyll molecule and write down the formula You may use it while discussing the minerals essential for plants

3 Get a copy of the electron microphotograph of a chloroplast. Label its parts Sketch one chloroplast as seen in light microscope.

4. Ask your students to compare and list the differences in the structure of chloroplast Ask them to make models of chloroplasts using plaster of paris, or paper, cotton, wooden box or whatever material they can get. Specify that they must show the type of action each part is doing. Relating function and structure is an important concept in teaching Biology.

Do you know any animal having chloroplasts ? Is the term 'green revolution' related to chlorophyll ?
Do all the steps of photosynthesis take place only in chloroplasts, or some steps are completed in cytoplasm too ?

Carbon Dioxide as the Raw Material

You can plan many experiments to show to your students that without CO_2 there is no photosynthesis. Your pupils, in groups, can perform such experiments. They may put one leaf of a plant in a transparent polythene bag containing KOH solution, while the other leaf of the same plant in another polythene bag but without KOH (See Fig 7.2). Alternatively, they may put

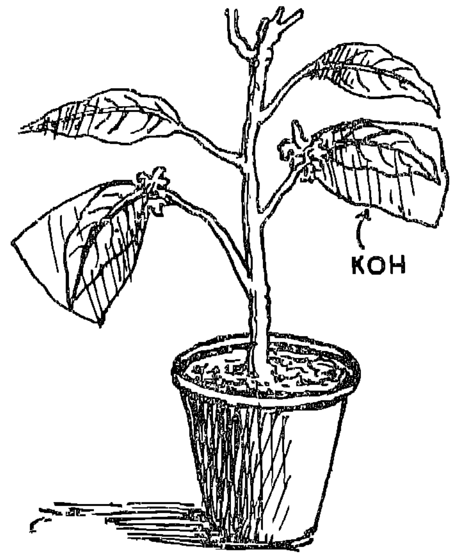

Fig 7 2 Experiment showing that carbon dioxide is necessary for photosynthesis.

a portion of a leaf in a flask through a cork divided into two longitudinal halves. Like the first case some KOH solution should be kept in the flask. You may try an experiment with water plants also Put the aquatic plants in a bottle or a polythene bag containing distilled water and compare it with one in which they put a piece of chalk as a source of CO_2. Discuss the results. Ask the pupils to plan more experiments for better results.

You can, of course, use the bell jar experiment to *demonstrate* that a rat died due to the presence of excessive CO_2 inside the bell jar in which no plant was kept. The rat remained alive in the bell jar in which

the plant was kept. Did the plant help in removing the excessive CO_2 from the bell jar ?

The Food Produced

You may recall that photosynthesis is the largest single chemical process on earth involving 200,000,000,000 tons of carbon annually. The total mass of living matter may be $=5\times10^{17}$ g i e. 100 mg/cm^2 of earth surface The total carbon photosynthetically incorporated into green plants during the history of the earth is approximately 10^{20} g, which is equal to $\frac{1}{50\text{th}}$ of the weight of the globe. It is estimated that 10^{21}g of this carbon is still present in the form of fossil organic compounds as coal, petroleum, etc

For You to Do

Make a chart as shown in Fig. 7.3

1. Ask some pupils to balance the figure by counting the molecules. Then ask them to write the equation and balance it.

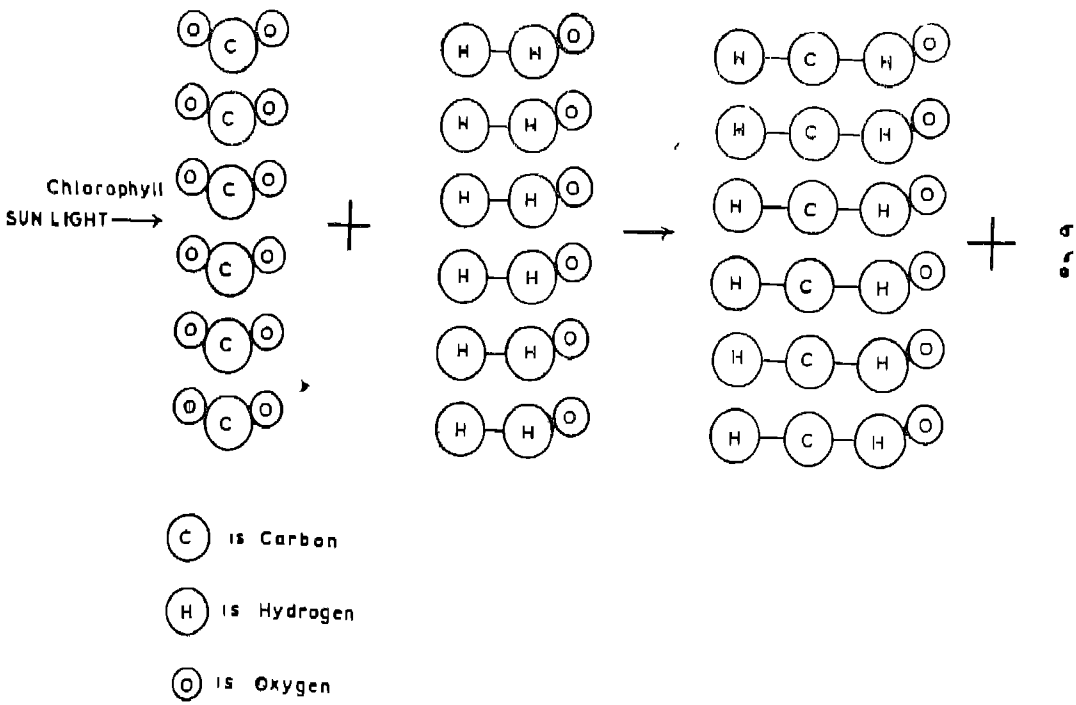

Fig. 7.3

2. With the help of charts discuss the light reaction, the dark reaction, and the fixation of CO_2 (Fig. 7.4). Sketch the cycles in such a way that your pupils can distinguish the steps that are going on in the chloroplast and the cytoplasm of the cell
3. Here is a list of some of the extreme conditions in which plants can perform photosynthesis. Study the list and consult literature to find optimum conditions.

—Make a chart to use in the classroom.
—Devise experiments to show the students.
—Plan a project for a group for a science exhibition or a science fair

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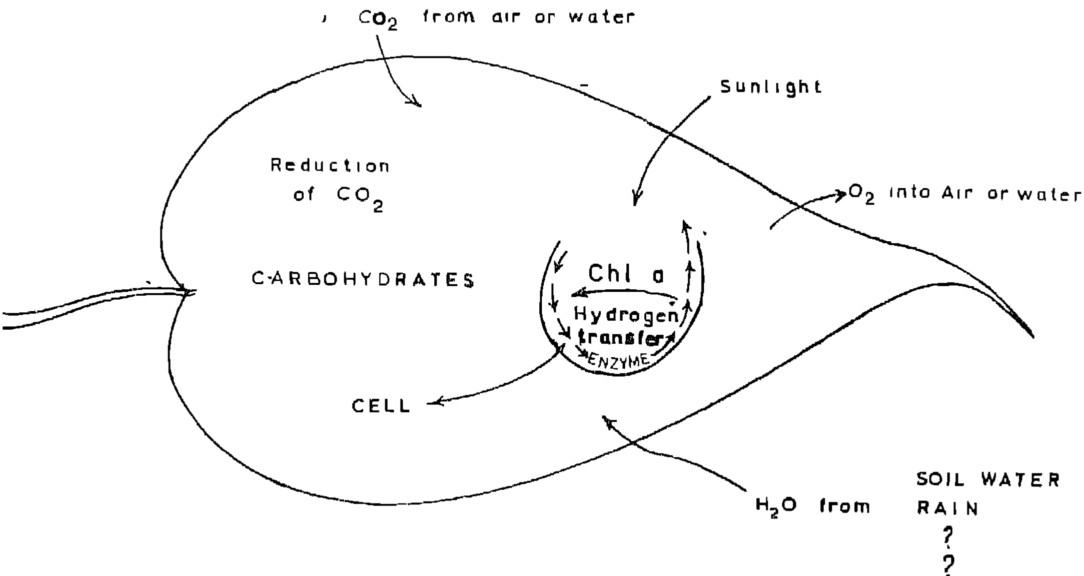

Fig 7 4 Diagram shows the light reaction, dark reaction, and fixation of CO_2

Factor		Example
Temperature	95°C	Blue green algae
Hydrostatic pressure	1070 atm	Deep sea forms
pH	12 0	Blue green algae in kenya lakes
Current	0 83 volt	Anaerobic organisms
Salinity	220 parts per thousand	Halotrophic bacteria

4 The primary end product of Calvin cycle in photosynthesis is 3-phosphoglyceric acid (PGA), a C_3 compound. In some plants like sugarcane, maize, and in many others, especially nonsucculent xerophytes, the end-product is a C_4 compound (dicarboxylic acids such as oxaloacetic, malic and aspartic acids).

Why some plants are called C_4 plants? Why are they mostly tropical or non-succulent xerophytes? Plan how efficiently you can introduce this difficult concept to your class.

Prepare a list of C_4 plants (consult encyclopaedias or McGraw-Hill Yearbook of Science and Technology (1971). This may be useful for your students.

You may ask pupils to prepare charts or models of various cycles You may help them try various other materials, maybe drawing pins of various colours to distinguish CO_2 and the end-products etc

Give them an assignment to sketch a graphic cycle of a C_4 plant.

Using tracer elements, or isotopes we can study the metabolic processes. Introduce the concept and ask the class to prepare their charts.

(*a*) (First Group) when O^{18} is isotopic in H_2O used by the plant.

(*b*) (Second Group) C^{14} is isotopic in CO_2 taken by the plant.

Assignments

Study from the books the measurement of carbon assimilation by enclosing a plant or a leaf in sealed transparent chamber. Pass air through the chamber. The decrease in CO_2 is measured by absorbing CO_2 in KOH. Titrate the compound.

Infrared gas analysers are also used by the scientists. These analysers are adapted for CO_2 absorption spectrum

Refer to the outline at the end of the unit and write what activities you will plan to teach that O_2 is a product of photosynthesis, and that plants as producers support the ecosystem.

Relate this topic with respiration. Discuss the relevance of studying the two processes together

OUTLINE OF THE UNIT TEACHING PHOTOSYNTHESIS

Major Concepts	*Major Points/Concepts in School Level Content*	*Planning Activities for You*
1	2	3
The basic source of energy for life processes is light energy.	1 Photosynthesis takes place in plant cells containing chlorophyll Water and CO_2 are the materials essential for the process.	Where is chlorophyll present ? Do non-green plants/parts of plants make their own food ? Are you sure plants take CO_2 and water ? Test it in the laboratory *Devise experiments* for your class Write what are the
	2 Light stimulates the process, remaining steps occcur with or without light	handicaps. Which plant material will you select from your locality ? Which plants have more photosynthetic rate? Write a few points to relate it to the food problem Discuss how and how
Organisms interchange matter and energy with the environment	3. Light energy is stored as chemical energy	much photosynthesis will take place at poles or deep in lake/ocean, in Siberia, or in your own town
Photosynthetic process is basic to the metabolic process in all living beings	4 One of the products O_2 is released into surrounding environment; the other product, glucose, helps in the growth of the plant through its living processes	What will happen if no light is given to a plant for many days. *Draw* a leaf so as to differentiate light and dark reaction *Plan an exercise* for students *to sketch* graphic representation of light and dark reactions. *Make an objective type test* to see if students differentiate between various forms
	5. Photosynthesis and respiration are interdependent and are also related to the environment.	of energy
Organisms are interdependent on each other and on the environment	6 Plants are the producers, the food synthesised by them is consumed by all other organisms called consumers (Do they take something in return ?)	Can we *substitute* light stimulus for initiation of photosynthesis with any other stimulus, say, electric current ? If so, why ?
		Which of the wavelengths (colours of spectrum) stimulate photosynthesis ? *Plan an experiment* to give it as a *project work* to a group in your class. How will you help them with the *recording data* ? *Take them around* to open fields, cultivated area, greenhouse, kitchen garden, verandas and

1	2	3
		laboratory, and discuss the light conditions and photosynthesis
		Devise experiments to show that a gas is a product of this process Now *test the gas* and help them conclude what gas it is
		Test the products of photosynthesis *Prepare stains* and plan a *laboratory exercise* so that pupils test it themselves Give a project to a group of four students to compare it in different plants of the locality they select.
		Plan a *ten-minute discussion* about how a plant can store and utilise in itself its end-product. Encourage them to write in tabular way rather than just speculating verbally.
		Plan a home assignment for pupils to sketch the process of photosynthesis *Make a chart* to show the steps in a linear fashion
		Devise a game One group writes or takes the steps of photosynthesis from a book, and writes them in reverse order. Another group does it for respiration Compare reversed photosynthesis with respiration and respiration with photosynthesis (One point for each difference; two points if the other group contradicts it, let you be the judge).
		Take students to the field, and distribute an area of 200 square metres to each group. Assign to the first group, a tree, to the second, a pond, to the third, a lawn, and so on Ask them to count plants (how ?). Think how many animals (from ants to man) can their area support Do they need more land to support the animals in their area or have they some surplus for more animals to support ? *Ask them to list dangers* if more animals (what types) infiltrate in their area.
		Ask your pupils to write an essay on how to utilise more solar energy for more photosynthesis.

Method Used

In teaching the topic of photosynthesis, students are motivated by narrating an historical account on various beliefs about photosynthesis. Then the students are given some activity based on the historical experiments using some innovative method. Various other concepts such as light stimulate the process; the pigment and site of photosynthesis, and carbon dioxide as the raw material are taught through activities Some demonstration can also be given regarding carbon dioxide as raw material The chart has been used to teach Calvin cycle. If charts are not available then you may draw a good diagram on the blackboard. The use of blackboard is also important while writing various chemical equations.

You may develop some other methods keeping in view the local environment and the resources of the shools. Prepare teaching notes.

Assessment

1. What do you suppose is the serious disadvantage in the structure of the leaf ?
2. Write a paragraph summarizing how the leaf structure is adapted for photosynthesis ?
3. How do you think the green cells are supplied with carbon dioxide and water ?
4. What tests will you use to tell whether photosynthesis had been occurring ?
5. If CO_2 can enter through the stomata, then water vapour can escape through the same openings. Describe an experiment that would test the hypothesis.
6. How would you find out whether there is a relationship between the number of chloroplasts per cell and the classification of plants ?
7. Divide the unit into two lessons. Re-sequence the activities you would like to plan for teaching.
8. Point out some improvements in the sketches, cycles or experiments suggested in the school textbooks.

CHAPTER 8

Respiration

Introduction

Respiration as a topic forms part of the curriculum in science at all levels of the school stage. In the primary school stage, the children observe breathing as one of the characteristics of living organism, which they find in their environment. In the middle school stage, it is mainly directed towards the establishment of the complimentarity between the structure and function of respiratory organs in animals and man including the mechanism of its functions. In the secondary stage, its perspective as an energy-yielding process is treated.

For a good understanding of respiration at the secondary stage, fundamental ideas of energy and its forms, the phenomenon of oxidation-reduction, and the role of different enzymes in controlling the process are required. Perhaps a team teaching-technique involving the Physics and Chemistry teachers for dealing with certain concepts might be necessary.

The teaching of respiration in secondary schools can be made very lively and stimulating to the pupils by engaging them in a variety of activities. If planned properly, the demonstrations, individual pupil experiments, individual and group projects can be performed with quite inexpensive glasswares and chemicals, to develop scientific enquiry skills, laboratory skills and also for achieving the objectives of higher levels of cognitive domain.

Major Concepts

1. Respiration is a process of oxidation of food which results in the release of energy for cellular activity in organisms.
2. Respiration, though similar to burning in many aspects, is distinctly different from it in certain important features.
3. Respiration is one of the basic physiological processes of all living

organisms : plants, animals and human beings.

4. Respiration is an intra-cellular process, whereas breathing is a process of gaseous exchange between organisms and their environment.
5. The organs of respiration which may be different in different groups of organisms show adaptations to their modes of life
6. The rates of respiration of an organism can be studied from the oxygen consumed or carbon dioxide released by it
7. The rates of respiration of organisms are affected by several factors which may be environmental or internal.
8. Quantitative relationships exist between the oxygen used and carbon dioxide produced during respiration in organisms
9. The ratio between the amount of carbon dioxide evolved to the amount of oxygen absorbed is Respiratory Quotient (RQ)
10 The actual sites of respiration are inside the cells, in organelles known as Mitochondria
11. The energy released by respiration is trapped in chemical compounds termed ATP (Adenosine triphosphate).
12 The release of energy undergoes a cyclic process (glycolysis and citric acid cycles are well known in respiration)
13. Respiration using oxygen, in which the breakdown of food substances is complete, is aerobic respiration ; and the respiration that occurs in the absence of oxygen, in which the breakdown of substances is incomplete, is anaerobic respiration.
14 The terminal phosphate bonds in ATP is known as high energy bond because it carries more energy than the other two bonds.

Higher Knowledge

Organic molecules such as carbohydrates, fats and proteins have energy stored in their bonds Respiration converts the chemical energy of organic molecules into metabolically usable form of energy within the living cells in mitochondria. The chemical energy of organic molecules ultimately represents stored solar energy. When the carbon bonds of organic molecules are broken under appropriate conditions, the energy becomes available for metabolic work

Respiration, in contrast to burning, does not produce the higher temperature of fire Burning is uncontrolled combustion in the sense that all the bonds within a fuel molecule may be broken simultaneously. A maximum amount of energy may be released all at once Such sudden explosive release of energy generates the higher temperature of a fire Respiration on the other hand is controlled combustion; energy is obtained from one bond at a time. If a fuel is respired completely, the total energy yield would be the same as if it were burnt in a furnace. In respiration energy is removed bit by bit, bond by bond and, therefore, the temperature remains low. Enzymes are responsible for this controlled combustion. Respiration is thus a series of chemical reactions which require enzymes.

The energy produced in a fire is dissipated mainly as heat and part of it may be as light. In respiration, only a small proportion of the energy escapes as heat and practically none as light. A substantial fraction of the total available energy is packaged

into a new chemical energy. The fuel energy thus creates new chemical bonds and it is in this form that metabolic energy is used in cells

Though any organic compound that contains bond energies may form the fuel of living cells under normal conditions, carbohydrates and fats in particular are favoured as fuel. The structural components of cells are decomposed gradually.

Principles Governing Experimentation in Respiration

You might be wondering that since food provides energy, whether the amount of energy potentially supplied by food can be a reliable measure of actual energy produced or of the energy requirement of the organism. All the food consumed by an organism may not be used toward energy production Some fraction of the food may be stored, another fraction may be used in synthesis rather than in respiration and some food may be eliminated unused.

A much better measure of energy release is the measure of oxygen consumption. As oxygen is not stored, it is used specifically in respiration It is taken into an organism in amounts geared precisely to its actual requirement. One can also determine how much fuel may be burnt with the aid of a given quantity of oxygen. Therefore, in planning an experiment for measuring the rate of respiration, you may base it on the amount of oxygen consumed during a particular interval of time by the organism.

The carbon dioxide released is proportional to the oxygen used by the organisms. The amount of carbon dioxide released by an organism during an interval of time also indicates the rate of respiration of the organism.

Activities for the School

You can introduce this unit in a number of ways which will enable you to capture and sustain the attention and interest of your pupils all through the lesson.

One of such ways could be to discuss with them their own familiar experiences of finding it difficult to run or play while fasting, or long distance runners getting exhausted after a few rounds of run. In the course of the discussion you may introduce ideas like 'energy' as the capacity to do work. You may help them recall that the food they eat provides energy and the 'energy' contained in the food is released by a process we call respiration.

This method of capturing the attention and interest of the pupils and sustain them during the teaching is known as Motivation. You can motivate the children in a variety of ways. You may ask a pupil (A) to observe another pupil (B) and count the number of times he inhales and exhales air in five minutes The count for the same interval of five minutes can again be made after the pupil (B) has jumped for five minutes. This activity could form a basis for your discussion.

If you are given either a photograph or a cutting from a magazine of the pictures of underwater divers and mountaineers with masks, how will you plan and guide the discussion for motivation ?

Demonstration

Obtain two wide-mouthed bottles fitted with two holed corks. Join them by a T-junction as shown in Fig. 8.1. You may look carefully at the way in which the tubes are inserted and arranged. You may set

up a similar arrangement. You might be familiar with the purpose of storing limewater in the bottles You may try this with indicator solutions in place of limewater Try to breathe in and breathe out air Make sure in which one of the two bottles the atmospheric air enters and in which one enters the exhaled air. Try-

In the above demonstration, if your pupil merely exhales the air drawn from outside into his mouth and keeps it in, in what way this can affect the result of your demonstration ?

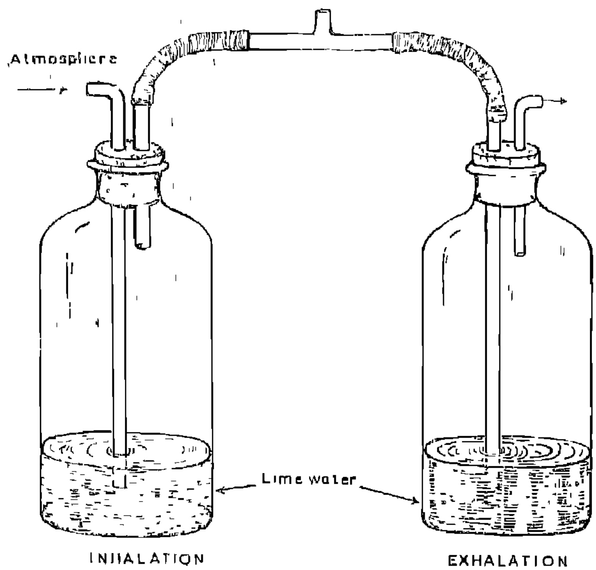

Fig 8.1 Diagram shows that during exhalation the release of carbon dioxide is more

out of the experiment is very necessary before you take it to the class and show it to your pupils. Can you think, why ? It gives you confidence. You can anticipate possible difficulties and be prepared to tackle them

In the classroom, when you show this demonstration, you may ask one of your pupils to breathe in air and breathe it out instead of yourself doing it. In this way you could involve your pupils in demonstration.

Individual Pupil Project

You can assign this work to a pupil whom you might consider to be a bright (gifted) one in science. Show a test tube to him and pose to him a problem that it needs to be divided into 2 chambers; one for keeping a grasshopper and the other for keeping the pellets of potassium hydroxide Put a condition that the two chambers should be in a position to exchange the air present in them, and the pellets of KOH should not come in contact with the animal You may show some examples including wire gauze for his selection, giving justification for it.

Help the pupil to bend a glass tube in the shape of U as given in the Fig 8 2. Let him make holes in the tight-fitted rubber cork for the thermometer and the for recalling the formula for calculating the volume of a column which he has already studied in his mathematics course Provide the necessary guidance for deter-

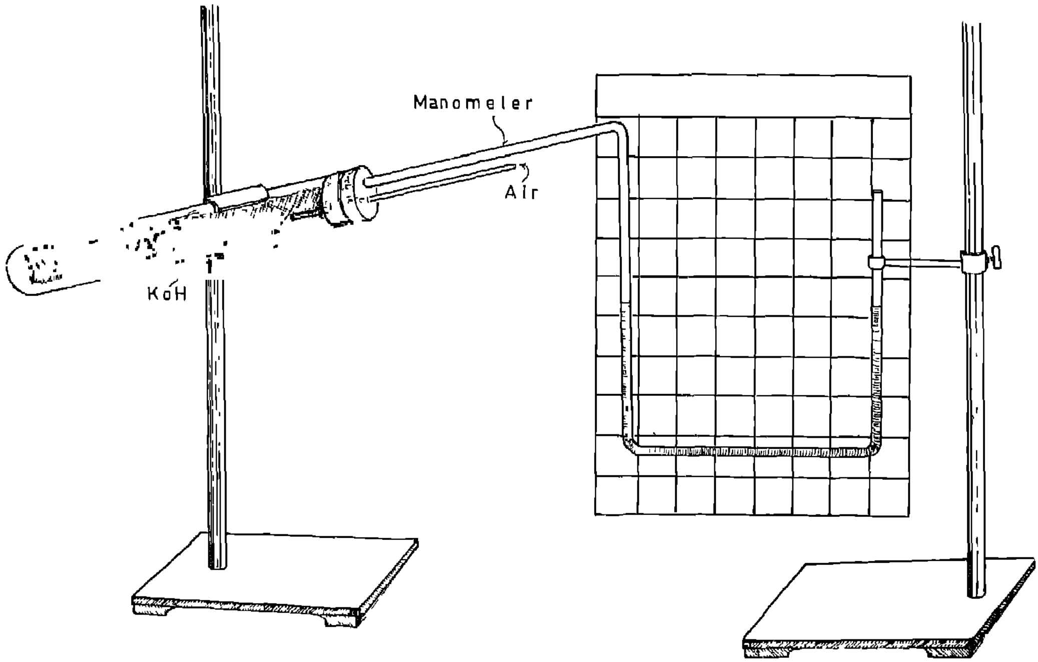

Fig. 8 2 Experiment to know the quantity of oxygen consumed during respiration

manometer tube. Ask him how he can find out whether the fittings are air-tight Let him also report to you the need for making it air-tight

Help the pupil fill the manometer tube with coloured kerosene to a limited height and fit it into the assembly Put an initial mark on the manometer tube Before you ask him to do, you should yourself try it out

After the assembly is ready you may announce the problem to be investigated— the volume of oxygen consumed by a grasshopper in 30 minutes Stimulate and encourage the pupil to give him ideas for solving the problem. Provide him a hint mining the diameter of the tube Discuss different possibilities. Let him test a few methods and choose the best.

Let him discuss with you the probable causes for the fluctuations in the volume of oxygen consumed by the same grasshopper at different 30-minute intervals.

Help him to report his findings to his class or in a science club meeting Encourage his audience to ask questions on the project to which he could give the answers

Report to your class fellows how the above mentioned experiment can be used as a Verificational (Illustrative) type and also as the Investigational one.

Demonstration of Estimating the Amount of Oxygen Dissolved in Water

Select wide-mouthed sampling bottles of 300 ml capacity Invert the bottle in a bucket of water and fill it with water. Stopper it with care to completely exclude any bubbles Discuss why any of the samples of water taken in the bottle is unsuitable if the bottle traps any air bubble in it Involve the pupil in taking 2 ml of manganous sulphate solution and 2 ml of alkaline iodide reagent using separate pipettes. Ask him to release the reagents well below the surface of the sample Ask the pupil to observe the nature of the reaction and precipitate formation Discuss the reactions involved. Make use of blackboard for writing the reactions and inferences After the precipitate settles down, carefully remove the stopper and add 2 ml of concentrated sulphuric acid Since the handling of acid by the pupil might be dangerous, you may take the acid and add that to the reagents in the bottle. Replace stopper and mix by gentle inversion until the dissolution is complete. Ask the children to note the colour of the reaction and discuss how iodine is released

Help the children to titrate with 0.025 N Sodium thiosulphate to a pale straw colour. Add 1 to 2 ml of freshly prepared starch solution and continue the titration to the first disappearance of blue colour

The demonstration can be made more stimulating to the pupil if you can take two samples of water; one sample of pond water or well aerated water and the other of sewage water. Since the intensity of the brown colour of the precipitates, formed in the bottle after the addition of the first two solutions, provide an indication of the comparatively higher or lower content of oxygen, it can be used for discussion to predict in advance of the sample that might have higher content of dissolved oxygen.

Help the pupils work out on the blackboard the amount of oxygen in the samples by making use of the formula that 1 ml of 0 025 N Sodium thiosulphate is equivalent to 0 2 mg oxygen/litre if the sample is 200 ml.

Group Project

Effect of body size on the respiration in fish/tadpole.

Select a group of pupils for the project. Have a mental picture of the background, abilities and interests of the individuals while forming up the group. Help the group identify the talent of its members.

Suggest the problem and ask the pupils to state the problem in their own words. Help them to define the scope and limitations of the problems after discussing with them the various conditions that can alter the rate of respiration in a fish or tadpole. Help them discuss the conditions like changes in temperature, pressure, activity of the fish, sex, etc. that can introduce errors into the data collected by them.

Let the pupils, after a few trials, report the method of weighing live fishes/tadpoles. Discuss with the group how the weight of fishes can influence the rate of respiration. Let them list the precautions and the controls.

Discuss the merit of finding out the rate of oxygen consumed in terms of one gram weight of the body tissue of the fish/tadpole.

Supervise their data collection. Guide them in tabulating the results, analysing the results, drawing graphs, and in the interpretation of data.

Plan for the preparation of the report

and its presentation in the class or in the science club.

Methods Used

The topic is introduced to the students by discussing with them their own familiar experiences. These experiences are then used to give them individual activities, so that they may feel at ease and have first hand experience regarding various physiological activities. After that you, may demonstrate to show that the quantity of carbon dioxide is more during exhalation. This gives an idea to the students that the more you work the more is the release of carbon dioxide. Wherever possible, you may give either an individual project or a group project to the students. The project should be well-planned. Details are given in the text itself. You may also think of many other such projects. What method will you follow while teaching krebs cycle or role of mitochondria as the power house of the plant ? Prepare your own note

Assignments

1. Give a design of two projects, one to study the rate of respiration in an aquatic animal, and the other in a terrestrial animal, at different temperatures (both above and below the room temperature). Make a list of all equipment necessary for the projects.
2. The photosynthetic activity of a plant releases oxygen which would cause confusion about the actual amount of oxygen consumed by the plant for its respiration. Plan an experiment to obviate this difficulty and estimate the rate of respiration of a small potted plant or that of an aquatic plant like vallisnaria or hydrilla.
3. Improvise an experimental set-up by which you can have continuous bubbles of carbon dioxide, produced by a terrestrial animal (e.g. rat) contained in a bottle, channeled into another bottle containing an indicator solution. Find out different types of indicator solutions and their use.
4. Set up an apparatus—the gas analyser—as shown in Fig. 8.3.

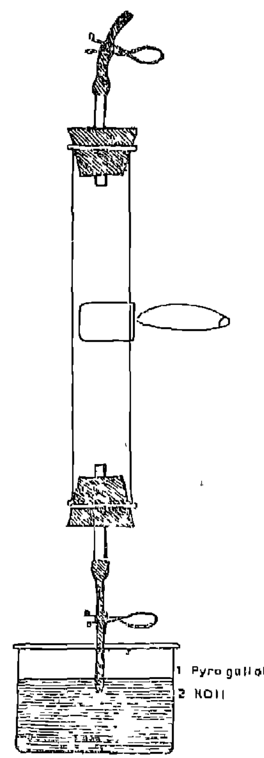

Fig 8.3. A gas analyser

Understand how the apparatus can be used in finding out the composition of air. Pyrogallol, a solution of pyrogallic acid in concentrated potassium hydroxide, has the

property of absorbing both oxygen and carbon dioxide. You already know that potassium hydroxide alone absorbs carbon dioxide only. Thus, by using pyrogallol and potassium hydroxide successively, it is possible to measure the amount of gases present in a given volume of air.

Show the set-up to a group of children and discuss with them how this can be used for investigating the composition of (*a*) Exhaled air, (*b*) Atmospheric air. How will you fill the chamber with air? Try it after filling the chamber with water and replacing it with air. Observe all the necessary precautions while using potassium hydroxide and pyrogallol. Consult your chemistry teacher.

5. Collect information on the life sketch of internationally renowned British biologist, Dr J.B S. Haldane, F.R S Prepare a short account of experiments in respiration which he carried out on himself. Prepare the life sketch and experimental work on respiration—suitable for display on the bulletin board.

Which do you consider will be a suitable occasion for discussing the above with the children of a secondary school ?

6. Help the children of the secondary school to obtain data on the rates of breathing under the following conditions, and work out the averages :

(*a*) Breathing rate after forced breathing for 10 minutes;
(*b*) Breathing while rebreathing the same air using a plastic bag;
(*c*) Breathing after an exercise for 10 minutes.

7. Help the children obtain data on the vital capacity of children of different age-groups, (boys and girls), young people, middle aged and old people. Supervise the groupwise analogies and recording of data and plotting histograms of the average data.

8 Collect information on the following by referring to books on human physiology and the encyclopaedia :

(*a*) Total surface area of the lung tissue of a man if stretched out.
(*b*) Total length of all blood capillaries that occupy the lungs of a man
(*c*) Amount of blood that is carried to the lungs in a day in a man.
(*d*) Amount of oxygen consumed and carbon dioxide given out during a 24 hour period of varied activities in a man

In what different ways the above data can be made use of in biology teaching, science club activity and for bulletin board display ?

9. Prepare a list of reference books which the pupils of a secondary school can consult to prepare popular articles on the following :

(*a*) Lung diseases ,
(*b*) Harmful effects of air-pollution on lungs and human beings ;
(*c*) Iron-lung . principles of its working and use.

10. (*a*) Plan an experiment to show fermentation by yeast.
   (*i*) How can you keep oxygen away from the glucose solution ?
   (*ii*) How can you drive away the oxygen present in the glucose solution ?
   (*iii*) What could be the use of liquid paraffin in this experiment ?

(iv) How can you show that carbon dioxide is produced during fermentation ?

(v) What would be the use of a thermometer in this experiment ?

Consult your chemistry teacher on the use of diazine green (janus green B) This dye turns pink when oxygen is in short supply around it.

(b) Work out a control for experiment 10 (a).

Winkler Method for Estimating Dissolved Oxygen

The estimation of oxygen dissolved in water can be done through Winkler Method There are many modifications of this method.

Principle of the Procedure

The procedure entails the oxidation of manganous hydroxide in a highly alkaline solution. On acidification in the presence of an iodide, the manganous hydroxide dissolved and free iodine is liberated in an amount equal to the oxygen originally dissolved in the sample. The iodine is titrated with a standard sodium thiosulphate solution using starch as indicator

Preparation of Reagents

1. Manganous sulphate solution: Prepared by dissolving 48 g of $MnSO_4\ 4H_2O$ in about 25 ml of distilled water and making up to 100 ml.
2. Alkaline potassium iodide reagent . Prepared by dissolving 70g of KOH or 50g of NaOH and 15g of KI in 75 ml of distilled water. After cooling, it is made up to 100ml.
3. Starch solution : Prepared by adding about 1ml of soluble starch to 20ml of distilled water; boil and cool
4. Sodium thiosulphate solution (1.0 N) · Prepared by dissolving 24.82g of sodium thiosulphate in boiled and cooled distilled water and made up to 100 ml

Standard sodium thiosulphate solution (0.025 N) .

Prepared by diluting 12 5ml of stock solution to 500 ml, or by dissolving 0.6205g of sodium thiosulphate in freshly boiled and cooled distilled water and diluted to 100 ml.

Standard potassium dichromate solution ·

Prepared by dissolving 0.613 g of potassium dichromate (dried at 130°C) in 500 ml of distilled water The strength of this solution is equivalent to 0 025 N thiosulphate solution.

Standardisation of thiosulphate with dichromate is done by dissolving 2g of potassium iodide with 100 ml of distilled water and adding of 10 ml of sulphuric acid followed exactly by 20 ml of standard dichromatic solution It is to be placed in dark for 5 minutes and diluted to 400 ml and then titrate against thiosulphate

CHAPTER 9

Growth and Development

Introduction

Growth is a characteristic phenomenon of all living things The life-cycle of an organism starts from a single cell—the zygote which is the fusion product of the male and the female gametes. The entire structural transformation from zygote into an adult one involves a series of fixed chain of events In other words, the process of growth and development occurs in an orderly way You are aware of the fact that cell division results in an increase in the number of cells. This means an increase in the bulks of the body of the organism Does it mean that growth is merely an increase in the number of cells ? The term growth is frequently used to include most of the processes of a developing organism

The major concepts identified in this topic are the following :

Major Concepts

1. Growth is an increase in the size and number of cells in an organism, that is, an irreversible increase in its size.
2. The overall form of an organism is the result of interaction between its genotype environment.
3. A typical organism does not grow at a constant rate
4. Growth and development of a multicellular organism start from a single celled structure—the zygote.
5. All changes during growth and development are cellular events
6. Growth is also under the specific control of chemical substances called hormones, produced within the organism.

Activities for the School

Growth is an increase in the size and number of cells in an organism, that is, an increase in its size which is a permanent change.

A fertilized egg cell undergoes a series of orderly changes and forms an embryo which develops into an adult organism. You must have noticed from your experience that the adult organism reaches its peak and certain degenerative changes occur leading to its death. All these changes occur in a regular sequence with very little variation

How does the single cell called zygote become a large organism ? What is the mechanism which causes an increase in the number of cells and increase in the size of the organism ?

In unicellular organisms growth means, an increase in the number of individuals by cell division Growth is also an irreversible process.

Ask your pupils to *observe* and make note of the changes occurring in an infant. Let them also observe people of different ages.

Let them separate a healthy filament of *Spirogyra* and count the number of cells under a microscope. Ask them to place this filament in a petridish near any source of light in the lab. Observe the filament after 5-6 days again.

Do you observe an increase in the number of cells ? What is it due to ?

In this case growth is in the longitudinal direction while in the higher organisms it is in all directions.

You can also ask your pupils to place a few bean seeds on a wet piece of blotting paper in a petridish and cover it. Let them *observe* after 4-5 days when the seeds germinate

What changes do you observe ? Do the roots grow ?

Observations have to be made for some days. They can also mark the roots at equal distances and find out at what region elongation is more. At the point where most of the lengthening of the root takes place, the marks will be farthest apart.

Experimentation, Observation
What is the lengthening of the root due to ?

The overall form of an organism is the result of interactions between its genotype and environment in which it grows.

We have noted in the beginning that growth is an increase in size and number of cells But it should be remembered that the total development of an organism involves something more than mere increase in size. If it were only an increase in the number of cells, the whole organism would have become a shapeless mass But this does not happen. An organism passes through a fixed chain of events which lead to the sequential development of form and physiology, characteristic of a particular species. You know that a mango plant develops a shoot and root system unique to itself with a set type of roots, branches, leaves, flowers and fruits. This uniqueness or identity of form is due to the genetic composition which it possesses. In other words, the growth and development of an organism involve morphological and chemi-

cal differentiation according to a hereditary pattern. Internally, cell division and cell enlargement are followed by differentiation. The organisation of a great variety of cells into tissues and organs is due to the process of differentiation.

You might have observed that a number of characteristics of living organisms depend upon the environment in which they live. Individuals of a species grown under different environmental conditions may exhibit variations in their form and shape.

Let the students place some bean seeds in two trays. When the seeds germinate, ask them to keep one tray in the open area where it gets normal light and the other in a dark chamber Make observations after 10-15 days. Let them compare the two types.

Project work, Experimentation

Do you observe any changes in the plants which grow in light ? How do they differ from the ones which grow in dark ?

A typical organism does not grow at a constant rate

The pupils may be asked to sow some seeds of flowering plants in the school garden. Instruct them to observe the germination and to measure the length of the plant every week and make a graph of the length against them.

Is the growth rate constant throughout ? What sort of graph do you get ? What is your interpretation ?

You can also tell them that increase in weight and growth of organs and cells can also be measured and similar graphs can be prepared.

What is 'S'-shaped sigmoid curve ? What is its significance ?

How does the growth of a plant differ from that of animal ? From your daily observations of animals you could have concluded that they have a restricted growth. While in plants there are localised centres of growth called meristems.

What are meristems ?

These meristems are present at the apices of roots and stems (apical meristems), the lateral side (lateral meristems) and intercalary regions (intercalary meristems). Because of the activity of these meristems the growth continues in plants.

Assignments

1. Prepare the growth curve of a plant. Find out its grand period of growth.
2. Locate the apical meristems, lateral meristems and intercalary meristems in plants
3. Make a chart showing the sigmoid curve
4 By using different types of plants find out whether the sigmoid curve can be obtained for all of them.

The development of a multicellular organism starts from a single-celled stage—The Zygote

Zygote is a single cell which is the fusion product during sexual reproduction. In some cases its development starts in the external environment while in others, it develops inside the body of the mother. Ask the pupils to find out examples of both the cases.

You may narrate the different stages of the frog with the help of charts or preserved specimens If possible, during the rainy season a field trip to the pond may also be arranged to collect various developmental stages of frogs. After this, ask the students to arrange the stages serially as given in the book/chart. Let them also sketch various stages and make brief notes.

Bring some fertilized eggs from the poultry Keep them in an incubator at 37 7°C After a period of three weeks the chickens will come out of the eggs. Here you may emphasise that the fertilised egg is a zygote Then you may correlate that the babies are formed from the zygote

Students may also be asked to collect information either from books or hospital about the development of human beings

Narration followed by activity

Assignments

1. Collection of various developmental stages of the frog. Making charts and models of the same.
2. Collection of photographs/preparation of charts of various developmental stages of the human embryo.
3. Observation of the developmental stages of chick embryo into an adult.

All changes during development are cellular events

In the early stages of development the embryos of different animals look alike. The differences appear only at later stages How does the complex form of an individual appear from a simple stage ? How is it that the different tissues and organs are formed from a single cell ? You may inform the students that the whole developmental process is a series of cellular events which lead to the structural complexity of the organism The cellular events are :

1. Cell division and growth
2. Cell elongation
3. Cell movement
4. Cell differentiation, and
5. Cell death

This concept may be further reinforced with the help of charts showing the series of cellular events and ultimately the structural complexity.

One point which needs to be emphasized is that development is a process that does not end with the formation of an adult. As changes occur even in the adult, the aspect of development covers the whole life span of the individual, from the formation of the zygote to the death of the individual

Cell division results in multiplication of cells. Cells multiply by mitosis. In the early stages of development mitosis may be synchronous In plants, mitosis occurs throughout life in the growing parts, while in animals the rate of mitosis reduces as the growth is restricted.

Where does mitosis occur in an adult man ?

After cell division the cells begin to assume their mature characteristics. The first step in this change is a considerable increase in size. There is an increase in the bulk of the nucleus and cytoplasm and an enlargement of the vacuoles. This great increase in cell volume is one of the ways in which plant cells differ from those of animals. When the cell elongates there is a stretching of the cell wall. Along with the

stretching of the cell wall, a new cell wall material is synthesised The surface area of the wall is increased.

There is a considerable movement of cells during development. The movement of cells helps them to take their proper positions to develop further. Examples of the cell which gives rise to the reproductive organs in the chick and its movement through blood stream to occupy its exact position can be mentioned here

Is there any cell movement in higher plants ?

Cell differentiation follows the transfer of an abundant supply of food into the newly-formed parts In a developing embryo, cells change and attain a particular form to perform specific functions. Differentiation means the transformation of a homogeneous group of cells into different types of cells to assume different functions A cell once differentiated usually loses its power to be transformed into any other type of cell. For example, a muscle cell or a nerve cell cannot differentiate further into any other type.

Mention some examples of the differentiated cells

The last stage in the development is the cell death You can cite the example of replacing the dead cells in your skin by new cells. It can also be noted that the old blood cells are replaced by new ones after every six weeks.

Growth is also under specific control of chemical substances called hormones which are produced within the organism.

Animal hormones are produced by specialised cells in the body which constitute the ductless glands or endocrine glands. These glands discharge their products directly into the blood stream.

Name some of the endocrine glands in man

It should be emphasized that these hormones vary greatly in their composition. They are mostly sterols. Some are proteins, while some others are amino-acids. How does a hormone act ? Usually hormones induce specific physiological influences on other cells to elicit a particular response which may be acceleratory or inhibitory. A product of the thyroid gland promotes growth, while an adrenal hormone inhibits the movement of intestine. In insects, hormones control moulting, metamorphosis and migration. In vertebrates, hormones control important processes like growth, development, formation of skeleton, digestion and reproduction

Ask your pupils to prepare a chart of the human body showing all the glands which secrete hormones.

Plants have four types of naturally occuring growth regulators. These are auxins, gibberellins, cytokinins and abscisin. Out of these, auxins and gibberellins are well known growth promoters. Indole acetic acid (IAA) is an important auxin. Auxins are synthesised in the tip of the plants and in young leaves. Auxins enhance the rate of cell division. Immediately below the site of its synthesis auxin causes cell elongation. Auxin also influences the proliferation of root cells. It should be noted that auxins are more effective in minute quantities. The concentration of

auxin which causes elongation of cells in the stem, inhibits the elongation of root cells.

It should be pointed out to the students that hormones influence plant behaviour also. You can quote the example of a plant which grows towards the direction of light. Take a potted plant Keep it near the window through which some light is coming. After a few days observe the direction of the stem. Such movement towards the source of light is called phototropism. What is it due to ? It is known that auxins influence cell division. In this case the shaded side of the plant has more amount of auxin and therefore there is more growth This unequal growth results in the bending of the stem towards the source of light. The actual use of hormones may also be demonstrated or this may be given as a project to a group of students. Let others observe

Narration followed by experimentation and project

Methods Used

This topic has been taught by using the lecture method which is followed by various activities. At some places lectures are first delivered and activities are given later But at some places the students are first given some activities and on the basis of their observation, questions are asked and conclusions drawn Since some activities are time consuming, some projects are also suggested. The concept "all changes during development are cellular events" is purely theoretical, and hence the lecture method has been followed. Chart is used as a teaching aid in the lecture method.

Assignments

1. Arrange field trips to a hospital and a pond. Acquaint yourself with various stages of development of a human being, a frog, etc.
2. Practise to incubate the hen's egg, arrange serially the different development stages of frog.
3. Prepare charts on cell division.
4. Practise the use of auxins.
5. Learn the effect of environment on organism.
6. Sequence and re-sequence your teaching strategy.
7. Compose your own notes on how to teach the concept.

CHAPTER 10

Gene

Introduction

Creation of life took billions of years because it had to occur by physical and chemical changes. But after the formation of nucleic acids, creation of life became a very rapid process. Today it takes hardly 20 minutes to create a new bacterium, and only 22 months to create a new elephant. Genes, the modern descendants of the first nucleic acids are present in every cell and perform controlled planning for creation and maintenance

You may relate this topic to the study of genetics, the cell structure and function, populations, origin of new species and biosociology of man You will have to plan how to introduce this topic in your class according to the earlier knowledge in cell biology.

Major Concepts

1. An organism is the product of its heredity and environment.
2. The code of heredity is found in DNA.
3. Genes are the basic units of inheritance.
4. Genes may be a specific site for mutation, recombination or biochemical action

Concepts in the School Level Content

1. Traits, although inherited, may be influenced by the environment too.
2 Genes are organised into large units called chromosomes: the latter are located in the nucleus of the cell.
3. A gene is a unit of DNA molecule.
4 Genes are very stable.
   (*a*) Gene mutation is a change in genetic material, not a loss.
   (*b*) More than one kind of mutation is possible for any particular gene.
   (*c*) Rate of mutation may be modified experimentally.

5. Gene may be a muton, recon or cistron.
6. A gene has an envuonment of its own.
7. Scientists are busy engineering the genes for human benefit

Activities

You may introduce the topic by discussing the inheritance of blaze hair Some people have a streak of white hair running back from the middle of forehead called "Blaze Hair". This is a hereditary "Trait". You can ask your pupils "Why didn't you have blaze hair ? Would you like to know why ? Would you like to know how people inherit traits ?" You can recall that science of heredity is called Genetics. About 100 years ago an Austrian monk at Brunn (now in Czechoslovakia), Gregor Mendel—'the father of genetics'—was the first to discover some basic principles of this science and record his observations for others to know

What is a trait and what is a genetic trait ?

Ask your students to write in their notebook as many traits in human being as they can You may give some instances. Do all the traits run in families or some are not true to heredity ?

Heredity or Environment

Pose your pupils a problem. Why is grass green ? Has it inherited this 'trait' ? If so, would a grass grown in dark chamber be green ? Reason out the alternatives they give.

Sometimes two babies are borne by the same mother at the same time. Such babies are called 'twins'. They may be 'fraternal twins' (if they come from two different fertilized eggs) or 'identical twins' (if they come from a single fertilized egg). Although they are almost exactly similar, yet there are some differences. (You can prepare a chart of identical twins and ask the students to search for the differences, if any) Prepare a table of one of the investigations · 63 individuals with diabetes were found to have identical twins, only 53 pairs had inherited the disease. Similarly, 52 pairs of 80 tubercular individuals were found to be carrying tuberculosis. Why did not the rest carry the disease ? Yon may discuss with your students the role of environment.

Suppose one partner of the identical twins is fed better and is given better education than the other, will there be differences in their I.Q., body weight and smartness ? Why ?

Carrier of the Traits

How are these traits carried from the parents to the offspring ? Assuming that your students have already studied this under Mendelism, you may try to derive an answer to "What is the exact locus and how does it look ?"

Guide your pupils to make a stained preparation of their cheek cells. They can stain it with iodine. Advise them that sterilised needles should be used to get a scratch for cheek cells. If your pupils fear that their cheek may get injured they can take onion peels. Exmine the preparation under a microspope You may put ocular scale in the eyepiece of the microscope and help them in measuring the cell and the nucleus. (Each space between the smallest marks of the scale is equal to 50

microns, 1000 microns = 1 millimeter). Suggest to your pupils that even if their measurements are rough, they can take the average of the whole group. Help them observe and record their data in a table (observational chart).

Help them to form a hypothesis of their own Suppose the nucleus is 5 microns in a 100 microns cell. This nucleus is packed with as many as 46 chromosomes, and in these chromosomes are present all the genes responsible for hereditary traits. What is your hypothesis on the size of the gene ? Let them calculate on a piece of paper. Using the above statement ask your pupils to refer back to their previous knowledge and explain :

(*a*) why do genes occur in pairs ?
(*b*) why are the two members of the pair derived one from each parent ?
(*c*) why do genes segregate in meiosis ?

Give your students an assignment. Select any trait out of the list they have already prepared It may be the colour of the eyes, hair, curly hair, straight hair, length of fingers, complexion, premature grey hair, length of arms, quality of teeth, blood groups etc. Ask them to find out if they resemble either their mother or father. Then try to find out which relatives on their mother's/father's side possessed the same trait. If possible, carry the investigation to as far back as their grand parents. Ask them to prepare a diagram in note-books to record the facts they discover. Signify if the trait seemed to be dominant, recessive, or incompletely dominant. Ask them to invent a symbol to signify the occurrence of the trait and place it at proper places in the diagram. Do not omit to explain the symbol (may be a circle will represent woman and a square represent man).

Single Gene or Many Genes for one Trait ?

You may narrate one or two examples of single gene effects in man, say, blood group. Likewise, many traits such as eye colour, colour of the hair are multiple gene effects as more than one genes are required.

Ask them to go to the library and make a list of single gene effected and multiple gene effected traits in man.

Were the traits studied by Mendel single gene effects ? Give reasons for your answer

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One Gene One Enzyme Theory

You can try enquiry approach to stress that genes synthesise enzymes and each gene is responsible for synthesising a specific enzyme. Your pupils will also appreciate that how simple organisms like *Neurospora* can be used for such difficult concepts that while earlier scientists used higher animals and plants (*Drosophila*, *pea*) there is a trend to use lower organisms too; and that indirect methods could be used to prove that we cannot see and observe directly.

Does one gene synthesize one enzyme only ?
Should many genes act together to synthesise one enzyme ?
Could one gene synthesise more than one enzyme ?

Nature of Gene

By questioning make the students recall the structure of DNA (you can also show model or chart to recall) Try to help them

make double helix models of DNA. Ask each group of your pupils to use different materials. Credit the group which uses simple materials, yet makes a distinct model. A suggestion can be given for using two tongue cleaners of same colour and beads of four colours Likewise, they can choose representatives of phosphates. Needle and thread can be used to make the model. Twisting the ladder would simulate Watson & Crick's model of DNA. Do not forget to represent it, bonding and inverting one of the tongue cleaners. Do you know why ?

Show the pupils some of the prepared models and ask them to make one of their own, maybe by using reed cane pieces and some wire pieces, etc Pose to the students a simple problem. Suppose they have to search some thing hanging on the wall of a dark room, how will they search ? You may do so by hanging beforehand some pieces on the wall of a big box where the pupil can put his hand, observe and give the hypothesis.

Gene size was studied in somewhat similar way X-ray particles are showered and the genes, which are hit, can be studied. Scientists have studied the genes this way and have 'mapped them'.

"Accidents"

In the models of DNA shown by you to the students, you may replace one base with another Ask your pupils to notice the change and hypothesise what changes it may cause to the organism (assuming that pupils know the function of DNA).

Ask your pupils to observe in the field or the surroundings where you may take them to search for some such abnormal plants/animals which do not resemble the normal lot (for instance, a coloured flower in a bed of pure white *Lantana*, a red coloured sweet potato among the normal coloured sweet potatoes, an 8 ft tall chilli plant among normal-sized plants, etc.). Ask them to list such 'accidents'. Can they hypothesise the causes ? As an exercise you may encourage some students to put them separately and observe such plants for following generation too, if possible.

Biologists call such accidents *mutation*. Dr. Herman J Muller discovered in 1927 that the genes in Drosophila can be changed by bombarding the fly with x-rays. Dr. Muller was awarded Nobel prize in 1946. How often do mutations occur in nature ?

Scientists have estimated that in man, there are one in 10^5-10^6 chances in one generation, while it may be one in 10^{10} in bacteria.

Discuss with the students the various causes of mutation and develop the concept that mutation takes place at a point in DNA which may be called a gene—scientists prefer to call it 'muton'.

Is this gene new to the organism ?
What changes will it cause in the organism ?
How can this process lead to origin of new species or varieties ?
Study some examples where this phenomenon has been used for human benefit

Would you conclude that a gene consists of one or a few nucleotides as in muton ?

The gene of a bacteria isolated at Haward Medical School consisted of a linear chain of 3700 nucleotides.

After discussing the muton, recon and cistron in the class, give them an activity to construct a few of each category with the paper models.

Develop other concepts given in the school book emphasising diversity in their functions. Scientists are still studying to know more about the gene. They are trying to determine (know the composition and sequence of nucleotides) and modify it in the interest of man and his surroundings They call it genetic engineering. By mastering the technology of genes we may be able to eradicate many diseases, manufacture insulin in bacterial factories, transfer nitrogen-fixing gene from bacteria to plant and so on. You can discuss the future prospects of such studies.

Method Used

The topic of gene is introduced by motivating the students and by discussing some of the common observations in their environment. The discussion is followed by giving an historical account of Mendel's work. Later on the lecture method is used, which is followed by an experiment Some mathematical problems are also given Students are also taken to the fields to show them the variations in nature. Charts and models have also been used. Students are asked to make models, using various locally available materials.

Assignments

1. List some of the misconceptions in society about the inheritance of traits, (for instance, bad blood, transfer of traits through blood, etc).

Check if your pupils, after studying the lesson, still continue to have any of these misconceptions.

2. Prepare a chart, sketching identical twins (you can also take two photographs), Ask your pupils to point out differences if any

3. Do some laboratory exercises :

(a) Make stained preprarations of onion peels ; cheek cells ; a T.S. of a root tip. Measure the relative sizes of the cells and nucleus. Record it in a table.

(b) Squash young root tips of onion, or germinating gram seeds. Stain in Schiff's reagent, (Feulgen stain prepared from the dye Basic Fuschin . see *Microtechniques* by Johansons, or *Histochemistry* by Jensen for the method of preparation of stain). Count the number of chromosomes. Measure them.

Different groups in the class can select different materials for squash. List what difficulties you encountered, for instance, breaking of cover slip, etc

4. You can find out from the books the approximate number of genes in all the chromosomes in an organism. For instance, 20,000 genes on 46 chromosomes in man ; and 10,000 genes on 8 chromosomes in Drosophila. What is your hypothesis of gene ? What size range can it have ? A study says that all the genes of the world can be put in a space as big as an aspirin tablet

5. Prepare a chart of the number of chromosomes in various animals and plants around you. Extend the following list .

Organism	*n=*	*2n=*
1. Man	22+1	46
2. Beans	11	22
3		
4.		

6. Prepare a model of mitosis or meiosis. Girls can stitch it on cloth in various designs. Plaster of paris is an easier and more pliable material. Do not ignore the relationship between sizes of chromosome, nucleus and cell, which you have earlier established. This is a common mistake in most of the model and diagrams You may like to improve the diagrams given in your books.

7 (*a*) Make a list of traits Classify them as single gene effects and multiple gene effects; which character might have been inherited and which ones may be only due to environment.

(*b*) Feed one of the rats properly and keep the other rat starved. Do the traits developed in starved/fed rats are inherited ?

(*c*) The Himalayan rabbit has black fur on more exposed parts like ear, nose, tail and feet and it has white fur on the rest of the body. If an ice pack is placed at the back of these rabbits would you expect some changes ? Which is supreme—heredity or environment ?

8. Your blood group is a single gene effect, because only one pair of gene acted in producing it. The ability to test phenylthiocarbamide (PTC) is another example of single gene effect Try to obtain PTC test papers Chew a piece of it. Can you taste it ? Now ask each member of your family to chew and taste PTC test papers. Keep a record of it. If this ability is due to a dominant gene T list the genotypes. Make use of a checker board to find out the expected genotypes in your family.

9. *Search in the magazines* for the Nobel prize-winners who got the awards for studies related to gene. Why geneticists are getting nobel prizes year after year, from Muller to Beedle & Tatum to Khurana and so on ?

10. *Make a chart* of the famous experiments conducted by Beedle and Tatum ? What were their conclusions ? Do we still agree with them ?

11 Make a list of the major research in the study of gene, mentioning the name of the worker, the material that he used (Mendel used pea) and the highlights of his work. Write the names of the Nobel laureates in red colour

12. Crop and cut out designs of AGTC on pieces of cardboard Trace and cut out copies of each design on pieces of different coloured papers. Be sure to mark each design with the appropriate letter A, T, C, G

(A) Suppose you have 1,000 such pairs, how many different patterns can you make by shifting one or another base ? You may be working 8 hours a day for perhaps a week Remember a single DNA molecule may have as many as 20,000 pairs.

(B) Make a few hypothetical genes. How many nucleotides would you assign for making a muton, and a recon, and a cistron ? Ask the pupils also to try after you have developed the concept.

13 Make two necklaces of equal length. You may use thread and 'pearls'. Natural perfection can only be achieved if you make the two exactly similar, as per the size of pearls, their sequence, spacing and locii. Could you call them a homologous pair ? What factors can cause the change in the two pearls of necklace ? What is the origin of these changes ?

14. List various mutagens. Classify them Classify and explain the mutations as lethal, sublethal, semilethal, neutral, beneficial, morphological, biochemical, sterility and fecundity mutations. Consult books on genetics or an encyclopaedia. This will give you the idea of variety of effects of mutations.

15. Write an essay on genetic engineering. Incorporate the latest researches from popular magazines like Science Today, Science Reporter, etc.

Now condense your essay in 200 words for VIII Standard students and XI Standard students

16. Re-sequence the activities in such a way, assuming that

—your pupils have no knowledge of Mendelism ;

—your pupils have studied the structure and function of DNA

Assessment

How can you assess what your pupils have learned ?

1. Without referring to the text, sketch out a model of DNA.

2. DNA, Ribosome, transfer RNA, messenger RNA, amino acids, and proteins seem to act in a step by step process Describe the sequence

3 How does the concept of gene changed over the past 100 years ?

4 What was the hypothesis of Beedle and Tatum ? What were their conclusions ?

5 Give evidence from at least one study to indicate how each of the following acts as the environment of gene.

a the other genes in the nucleus;
b. the cytoplasm;
c. the internal environment of organism,
d. the external environment of organism

6. Why is DNA called the boss in the development of organism ?

7. Have we found out all we need to know about the action of DNA ? If not, propose what you think is lacking.

8 What evidence is there that in the development of a trait genes and cytoplasm act together ?

9 Is there any evidence, up to now, that an organism is not the product of its heredity and environment ? Give reasons for your answer.

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CHAPTER 11

Evolution

Introduction

The theory that a group, kind of organism, such as species, may change with the passsage of time so that descendents differ from their ancestors. The theory of organic evolution contrasts with the idea that each kind of plant and animal was separately created and has remained in its original form, the latter idea is known as the 'theory of special creation'.

Thales, 2,600 years ago, tried to account for the origin of organisms from four elements—earth, air, fire and water. The concept of change is not new Continents, mountains, oceans, rivers, stars and organisms have changed. Even you and we have changed.

Yon have to teach this topic in the total perspective of change in the living organisms as a continuous process. The concept of evolution can be developed, proceeding historically from the theory of special creation to Lamarckism, to the modern concept. To appreciate the process of change, your students should have a background of genetics, and ecological principles. A theory is borne in thought; it is borne in a careful synthesis, or putting together of many facts and concepts.

Major Concepts

1. There is a biological relationship among all organisms.
2. Organisms classified in a group have similarity in structure and function.
3. Closely related organisms have a common ancestry.
4. The hereditary code of organisms can change.
5. Organisms best fitted to survive in the environment give rise to other organisms.
6. Organisms have evolved from each other.
7. Like other organisms, man has evolved biologically and socially. In turn, man has modified the early environment.

Concepts in the School Level Content

For developing a theory you will have to discuss in your class the variety of ways in which organisms are related and they have had a long history. There are certain writings about this history still available as a proof of evolution

(*a*) DNA is basic to the inheritance of organisms

(*b*) Organisms are composed of cells.

(*c*) The chemistry of certain cells is similar in a variety of organisms Thus hormones (insulin) of certain animals can be interchanged, enzymes of one organism may act in another.

(*d*) Embryos of related groups of organisms show a close similarity (such as in vertebrates) They perhaps possess certain genes in common and hence a common ancestor.

(*e*) The anatomy (for instance skeleton) of related groups also show similarity in structure and function, suggesting common genes and hence a common ancestor.

(*f*) Fossil evidences indicate that organisms have had a long ancestry. Echinoderms lived 550 million years back, and mammals some 180 million years. Man goes back to some 1 million years. Also 2-3 billion years ago the algae, fungi, bacteria and simple invertebrates were widely prevalent. The earth is 5-6 billion years old. Mountain ranges and rivers have come and gone. Environments have changed.

Activities

1. Ask your pupils to collect sunflower seeds, pods of beans, or pine cones to obtain seeds. Let them count the number of seeds in each. Encourage them to hypothesise the number of seeds which may survive. They can prove their hypothesis by trying to germinate them in pots. They would be surprised if you tell them that a single salmon produces 28,000,000 eggs in one season, starfish produces about 1 million eggs per season, frogs produce 20,000 eggs per year. But only a small number reach adulthood.

What factors check the maturation of all the eggs or seeds of an organism ?

In another chapter on population in this book you may find an activity to germinate many seeds in a small pit, or germinating more seeds at one point. Try this in your classroom to develop the concept of struggle for existence.

You can also discuss this by showing an aquarium. How many fishes can this aquarium support ? What will happen if you stuff more fishes in the aquarium than it can support ? Would they all die, or a few may survive ?

2. Ask the students to get some seeds, may be of any pulse or those they can collect from the field nearby (Tephrosia has seeds with a great variations, and the size of the seed is convenient to handle). Let them examine the variations in them. They can use a hand lens for closer observation. Are any of the variations measurable ?

They may recollect the study of identical twins in the chapter on gene.

Are any two individuals exactly alike ?

Are twins always identical ? Discuss with them the function of the variations

they have observed. Are all variations helpful ? Ask them to list some such variations in plants and animals that may be helpful, harmful, or neutral. (For instance, the variation to retain water in desert plants, longer necks of giraffes, etc) Is a very beautiful flower helpful or harmful variation ? Likewise, after discussing step by step—the overproduction, struggle for existence, variation and survival of the fittest—you can show them the photograph and a chart of life history and works of Charles Robert Darwin (12.2 1809), who as a naturalist had a love for collection, had an open mind, and formulated the theory of evolution after his voyage on H.M S Beagle.

Compare the theory of Darwin with that of Lamarck and Wallace. Referring to the list of activities suggested for you and the list of concepts, plan your lesson to teach the evidences from :

a Geographical distribution

b Comparative structure

c. Cell structure and composition

d. Fossil records

Methods Used

In teaching the topic on evolution, activity method followed by questions is used Students are given some activities. On the basis of their observations they are asked to conclude. Thus they could realise themselves that a living thing requires optimum space and food, etc., to live. Field trips may be arranged to examine variations in nature They may see that things which look similar have some kind of variations. Charts/photographs have been used very extensively to show extinct animals. Likewise, you may plan your lesson to teach other concepts.

Assignments

1 Make a study in your area of one animal species or one plant species. Develop the ideas of variation, selection and isolation, to explain the adaptation to the environment.

2. Go on a field trip to study the changing earth in your area Perhaps you may find some fossils

3 Prepare reports on Lamarck, Weismann, Darwin, Mendel, de Vries, Morgan.

4. Your state's audio-visual department, Regional Colleges of Education, Ajmer, Bhopal, Mysore, Bhubaneswar, or NCERT, New Delhi, may have a film on evolution or mimicry or speciation. Discuss with your tutor, variation, section and isolation in developing new species.

5 Grow 4-5 different kinds of seeds (bean, corn, radish, pea) by planting 5-10 seeds of each plant in a pot. The pots should all be the same, keeping other factors constant . soil, light, temperature, water and position of pots. Observe the growth, number of seeds that survive and grow up to maturity. Relate your observations and results to the ideas of overproduction, overcrowding, competition, variation and struggle for existence

6 Compare cell structures Study algae, moss, fern, onion bulbs, bean leaf or other organisms Cut sections of multicellular organisms. Compare how each plant compares with the others Relate your observations to the theory of evolution.

7 Make a table of comparison of the salient features of Lamarckism and Darwinism. Do they have the same similarities too ?

8 Give your views on the theory of evolution. Do you agree with the earlier theories, or you may like to propose a new

hypothesis ? Do the theories of evolution fit into the social evolution of a society ?

9. Sketch maps of India and Australia (emphasising the boundaries). Mark the common animals (Kangaroo) and plants. Write a note on geographical distribution as evidence of evolution.

10. Make a list of vestigial organs in man

11 Fill a large jar with a mixture of sand, gravel and small rocks Put in shells, fish bones or chicken skeleton, bits of fruit and food. Add water, shake the jar and let it stand.

(*a*) Observe it after one week

(*b*) Put 2 ml of dilute HCl in 20 ml of water, add to a jar and observe after a week.

(*c*) Melt some paraffin and pour it on a paper square Place a dead insect in wax, let it harden What method of fossilisation does your model resemble ?

(*d*) Freeze bits of food in an ice cube Observe after a week the frozen state. Does it decay ?

(*e*) How would you explain the discovery of prehistoric animals in glaciers ? Once an elephant was found preserved fresh after hundreds of years of its getting trapped in a glacier. It had fresh blood. Compare your fossil models with defferent methods of fossilization that take place in nature.

12. Make an imprint of leaf. Pour "deep plaster of paris, put vaseline coated leaf, cover again with plaster". Let it harden Crack open Plan similar imprints for your pupils.

Assessment

1 Describe briefly how the following evidences support the theory that plant and animal forms developed from simpler forms :

(*a*) similarity of plants on mountain tops and in the arctic region.
(*b*) Similarity of structure of bats' wings, whale flipper and man's forearm
(*c*) The changes and growth processes of a chick embryo.
(*d*) Fossils found in the layers of the earth.

2 How cell biology contributed to the evidence supporting this theory ?

3 How did Darwin amass such an enormous amount of data to support this theory ?

4. List the main ideas in natural selection

5. List the main lines of evidence in support of evolution.

6 Define variations Why the variations in individuals due to environment are not important to evolution ?

7. What are the two basic sources of variation in heredity ?

8 Why variations are necessary for evolution ?

9. Describe each of the following points in natural selection and explain how modern long-necked giraffes developed from early short-necked giraffes .

(*a*) variation ; (*b*) overproduction , (*c*) struggle for existence , (*d*) survival of the fittest

10 Give an example of a genetic trait that increased a species' chance for survival and that caused the extinction of a species.

11. Suppose a giraffe taken to a zoo was fed very well and exercised often. Its neck grew 2 inches longer. Would this characteristic be transmitted to its offspring ? Why ?

12. How does a race develop into a new species.

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CHAPTER 12

Improvement of Crops

Introduction

This topic is very important for improving the quality of plants so that we may get more yield at low cost on the cultivable land. This has become all the more necessary because population is increasing at a very rapid rate. Cultivable land is also diminishing due to urbanisation and industrialisation. The only alternative left with us is to improve our production on the existing land. As a teacher you can help your pupils to understand how that might be done You will also need to remember or recall something about the methods which have been in use to increase production of crops.

Ploughing the land properly
Proper irrigation
Protection of the crop from animals and from diseases
Use of manure and fertilizer.

How would you use your knowledge of science to help children understand these methods ?

To teach this topic you will need to develop the following major concepts

Major Concepts

1. Introduction of a new crop and its acclimatization
2. Selection of better varieties
3. Hybridisation or cross-breeding to produce better varieties
4. Deliberate production of mutants.

What do you know about recent advances in crop improvement in India ? Where can you find information about it ?

Activities

In the classroom you might begin by describing the history of agriculture. In ancient days men used to wander here and there in search of food. They were dependent upon wild animals and wild plants. It would help if you had examples of wild wheat, wild barley, etc., to show to your class. Men started cultivating plants and

civilization began They started to settle in one place and sow seeds, water the plants and wait for the harvest. They were able to select the best grains for planting in the next season

Display of materials

To give an idea of introduction, you may narrate some instances—suppose a student from a school in the city comes and joins a school in the village or vice versa What will you say about that student ? There may be different answers to this question. You may note them down on the blackboard Students may say that he is a new student. You may clarify what exactly is the meaning of "new" —You may coin the term "introduce" After acquainting the students with this term you may switch over to plants, through a similar type of discussion with the students. You may help them in understanding the term introduction.

What other examples except plants can you think of where a living organism has been introduced to a new country ?

Teaching strategies ·
Narration followed by question-answer

1. **Are potato and tomato natives of India ?**
2. **How did the introduction of these plants to India take place ?**

An historical account of how travellers, pilgrims, invaders have helped the introduction of new species of plants in our country could be given The names of some other plants which have been introduced in India can also be given, such as tobacco, maize, groundnuts, chillies, papaya, quinine, rubber, cabbage, etc

The Ridley variety of wheat was obtained from Australia ; litchi and loquat from China , cherries, grapes etc. are brought from Afghanistan

1. **What are the home countries of tobacco, maize and papaya ?**
2. **Would it be possible to introduce any plant, or some selected plant, in your locality ?**

Certainly you could introduce selected plants If so, then there should be some criteria for selection. You may give two plants. One of them should be diseased and the other healthy Ask the students to compare, to count the number of grains per awn, if possible. Let them record their observations

Take some grains of wheat/maize, etc. Ask the students to select the best for sowing. The basis for selection may be (1) the germinating capacity of seed, (2) colour, size, weight (lightness or heaviness) and (3) appearance.

To test the germinating capacity of seeds ask the pupils to take 50 seeds and keep them on a moist paper in a covered jar. After some days note down how many of them have sprouted.

To estimate the lightness or heaviness of seeds take some wheat grain and put them in a pot containing water Count the number of grains which are floating.

1. **What will you do with the grains which are floating ?**
2. **What will you do with the grains which have settled down at the bottom ?**
3. **Why are the seeds which float on water generally unsuitable for sowing ?**
4. **Are all the seeds which float on water unfit for sowing ?**

From these activities the pupils may gain practice in calculating percentages, plotting graphs, making histograms, etc.

You may state that there is a law that if any person wants to go to a foreign country he will have to get himself vaccinated. Why is it so ? Similarly, plants cannot be brought into the country without the permission of checking stations These are called quarantine stations which are set up by th government. We try to keep away from the child suffering from infectious diseases. The same is the case with plants We should not allow any diseased plants/seeds in the country. From quarantine stations the seed/plants are sent to research stations/laboratories. Here they are tested for good yield and suitability to the new environment. Through discussion you may help them to understand the term quarantine.

1. Is qurantine necessary ?
2. Is the introduction of new plants always good ?

Narration is followed by question-answers.

You may remind the class that the student who has come to a new school on transfer takes some time to understand his friends, locality, teacher, etc. After some days he may or may not adjust himself to the environment. The progress of the student may improve or may deteriorate. Similar case is with the plants/seeds Through question-answer you may define the term acclimatization From this the pupil will understand the effect of climate and will know that change in climate is not always beneficial.

Assessment

Here are some questions you could set for the pupils .

1 Is improvement of crop necessary ? Give reasons in support of your answer.
2. What are the methods that can be used to improve crops ?
3 Suppose you have brought some plants from another country What procedures would you follow before planting them in your locality ?
4. When a person is suffering from some chronic disease, why does the doctor generally suggest a change of place with different climate ?

Method Used

To teach this topic, an enquiry approach has been followed. Here, while introducing the topic, narration of an instance is given —taking a student as an example This was later correlated with plants using the question-answer method. Demonstration and experiments were also given. Later, some questions are asked to strengthen the concept. If possible, field trip to research station/fields may also be arranged. You may think of any other suitable method. This you may learn by practice.

Assignments

1 From a heap of wheat grain select the grains to improve the crops. Sow them and select the grains from this crop. Repeat the process Make a table.
2. Prepare a map showing quarantine stations.
3. Practice how to demonstrate artificial pollination.
4. Sequence and re-sequence your teaching strategy again and again.

5. What teaching strategy will you adopt to differentiate unhealthy seeds from the healthy ones ?
6. Collect different varieties of wheat plant or any crop plant and compare the length of awn, the number of seeds, etc., of each plant with those of other.
7. Calculate the percentage of seed germinating capacity of different crop plants
8. Collect such seeds which float on water but are suitable for agriculture.
9. Collect samples of crop plants that show symptoms of diseases.
10. Make a labelled collection of natural and artificial fertilizers. Collect manufacturer's leaflets about their fertilizers.
11. Prepare pots and grow seedlings of plants which are grown in your district
12. Practice transplantation.
13. Compose your own notes on how to teach the concept.
14. Construct some questions to make the pupil think
15. Analyse the content into facts, concepts, etc.
16. Prepare an evaluation sheet.
17. Modify experiments for classroom activities.
18. Practice TTC (Tetrazolium chloride) viability test of seeds.
19. Arrange field trips to compare the same crop in different beds. Assign reasons and suggestions.
20. Find examples of plants which have been imported in India but have spread diseases.
21. Find out the agencies through which you can introduce a new plant in your locality.
22. Find out whether you can introduce a crop plant in your state from any other state of India.

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CHAPTER 13

Elements of Animal Husbandry

Introduction

This topic is very important because India's economy depends upon agriculture Cattle are the backbone of agriculture. A majority of people are vegetarian Milk and milk products constitute the only source of animal protein in their diet. Their milk requirement is not fulfilled with the present strength of animals Their capacity of doing work in the agriculture field is also not satisfactory Therefore, we have to improve upon their living conditions. As a teacher you can help your pupils to understand how that might be done.

Major Concepts

You should teach how the qualities of animals can be improved. The main methods include :

1. Scientific management, and providing good housing and hygienic conditions to the animals.
2. Providing balanced diet to the animals.
3. Taking care of sick animals.
4. Hybridization or cross breeding to produce better varieties.

What do you know about recent advances in improvement of animals in India ? Where can you find information about it ?

Activities for the school

In the classroom you might begin by describing the historical aspect of animal husbandry. From the very beginning man has been domesticating animals such as dog. Man domesticated cattle in order to use them for agriculture, for transportation, for getting food from them, etc. In this process he learnt and developed the techniques of management and selection of good breeds of animals. The accumulated knowledge in due course of time developed into the science of animal husbandry.

Display some pictures of wild and domesticated animals.

Why does man want to domesticate animals ?

After introducing the idea of domestication you may tell something about the cattle in India and their present position of cattle in India and their return comparing with that in other countries. You may state that the bovine population of India was 343 million which is more than 1/5 of the total population of the world (according to the census of 1966) In spite of having a huge force of cattle we get less milk, egg, meat, etc. from the animals as compared to the animals in other countries. For this you may prepare a chart (consult "Life Sciences for Classes IX-X," NCERT Publication 1975)

When the population of animal is so high, is there any necessity to improve upon animals ?

To give an idea of management, you may remind that your parents take care about your food, your clothing, your comfort, etc. Why do your parents take care of you ?

Do the animals need care as you need ?

Through question-answer the idea may be cleared that in the house parents manage food etc for us Then you may co-relate this idea that in a similar way the owner of the cattle manage the house, the food, the medicine etc. for them.

Cattle feed is classified as follows .

I Roughages

These are feeds which carry more than 18% of crude fibre, These are further classified into (1) Leguminous (2) Non-leguminous. Both these types of feed are green and dry.

Non-Leguminous dry feeds . This is termed as hay which is left over after threshing.

Most of the straws are poor quality feeds. They contain very little protein and a negligible amount of phosphorus. On the other hand ; some of the straws contain potassium which hampers the assimilation of other nutrients. They are, however, useful in satisfying the animals' appetite Example—Rich straw, wheat straw, jowar straw, oat straw, jowar hay.

Non-leguminous green fodders

All green fodders are rich in carotene and other vitamins and also in minerals. The amount and quality of fodder differ with maturity.

Example Mostly jowar, maize, oats and bajra.

Leguminous dry fodder

They are not an important feed because straws are very woody and hard. The protein content is higher. But protein in this cannot replace other nutrients for proper maintenance

Example Straws of gram and pea.

Leguminous green fodder

This is a good fodder rich in protein.

Example . Barseem, Lucernes, Guar or cluster of beans, lobia, peas.

II. Concentrates

It is a group of feeds which are relatively high in total digestible nutrients and low in crude fibres

Example : grains of cereals, millets, legume and their byproducts, oilcakes, feeds of animal origin and molasses.

The term concentrates is used because the nutrients are in a concentrated form as compared to those in the forage crops. Concentrates may be classified as follows

1. Grains of cereals, millets & legumes, maize, wheat, barley. They are rich in starch but have very little fibre.
2. By-products of grains etc.—straws of wheat, rice, oar, etc.
3. Oil cakes—coconut oil cakes, cotton seed and cake, linseed cake, mustard cake.
4. Animal products : (1) Fish meal—it may not be tasty for animals but should be given in a mixture, (2) Bone meal, (3) Blood meal. All these animal products are available in the market.

Feeds for the poultry are mainly cereals or their by-products The modern feeding for the poultry is the all mash diet. It is a mixture feed.

Similarly, there are different feeds for the pigs, sheep, etc. You may show different kinds of feeds. Ask your students to collect roughages and concentrates and classify them Make a collection of different kinds of feeds for the cattle, poultry, pig and sheep.

Pictures of houses, sheds of the cattle, pig, poultry etc may be shown. Models of houses for animals can also be made using waste and local material.

Do the young ones need special care ?

Apart from cattle management and animal nutrition animal breeding is also a very important phenomenon in the field of animal husbandry. Animal breeding is the first and fundamental step in the process of animal production. Animal breeding is the application of genetics and the physiology of reproduction to animal improvement.

The animal breeder has three basic tools for proper breeding

(1) Selection ; (2) Outbreeding, (3) Inbreeding (close breeding). Selection is based on record of performance, perfection of body etc The purpose of using record of performance is to focus attention more directly to economy of production—such as milk, butter, fat percentage, feed consumption and regularity of reproduction In poultry selection is based on egg size, fertility, hatchability, general vigour, marketable quality etc. Outbreeding—This is mating between less closely related individuals.

Inbreeding (close breeding)—In this process the mating takes place between relatives within a family It does not create any new gene.

Why the offsprings of good parents are good ?

A chart of important Indian breeds may be shown. If it is possible you may take the students to a cattle show. Pictures of Indian breeds may also be shown. Some of the important breeds are given below ·

Important breeds of cattle in India

1. Sahiwal
2. Red sindhi
3. Gir
4. Deoni
5. Haryana
6. Ongole
7. Tharparkar

8. Kankrej
9. Amritmahal
10. Kengayam
11. Malawi
12. Nagori

Important breeds of buffaloes in India

1. Murrah
2. Jaffarabadi
3. Nili Ravi
4. Nagpuri
5. Mehsana
6. Surti

Breeds and variety of fowls

There are 200 different breeds. These have been grouped into 5 classes.

1. American	1. Rhode Island Red
	2. Rhode Island White
	3. Plymouth rock
	4. New Hampshire
	5. Wyandotte
2. Asiatic	Cochin
3. English	1. Sussex
	2. Australorp
	3. Orpington
4. Mediterranean	1. Leghorn
	2. Minora
5. Indian	1. Aseel
	2. Ghagus
	3. Chittagong or Malay
	4. Busra
	5. Brahma

Important breeds of goats in India

1. Jamunapari	5. Barbari
2. Surti	6. Bengal
3. Beetal	7. Marwari
4. Pashmina	8. Malabar

Important breeds of sheep in India

1. Gurez	3. Lohi
2. Bikaneri	4. Mandya
5. Bhakarwal	7. Deccani
6. Nellore	8. Bandur

Important breeds of pig

1. Large white Yorkshire
2. Middle white Yorkshire
3. Berkshire

You may teach that if you take care of your animals the animals will give you more milk, more meat and other useful products You know that if you love your pet animals, for example the dog, the animals also return it in one way or the other. Show a chart of a cow reared under scientific management and unscientific management.

You may ask the pupils to observe how the owners of cattle take care of their animals Let the pupils collect data. How much milk a cow gives if properly cared?

Lecture & Demonstration

How does proper care of animals help us in getting better return ?

Arrange some extension lectures to be delivered by the owner of the farm or by a local farmer. He may tell the students how best you can help your parents in caring for the animals.

You may arrange a field trip to a cattle farm or a poultry farm nearby. Let the pupils observe there how the cattle are fed, groomed, protected from rain, heat and cold. If any animal is sick, what precautions do they take? After the field trip you may ask the pupils to write their observations and let them write their own notes.

1. What precautions would you take to protect the animals in the winter season ?
2. Is calf feeding different from feeding the cow ?
   Narration followed by discussion
   Fieldtrip
   Community involvement
   Demonstration

You may tackle the topic effectively if you keep in mind that human beings and livestock are symbiotic in many ways.

Assessments

Here are some questions you could ask them.

1. Students may be asked to compare between

   (*i*) The cattle on a balanced diet and the cattle not on a balanced diet.

   (*ii*) The cattle housed in sanitary houses and the cattle housed in dirty houses.

   (*iii*) The cattle under proper care and the cattle which are not looked after properly.

2. Which cattle will yield more ?

   Cattle under proper management, or Cattle under improper management ?

3. Why should we care for our animals ?
4. How will you plan a field trip ?
5. Which approach will you follow in teaching the concept "Care of Sick Animals" ?

Methods Used

In teaching the topic, mainly lecture-cum-discussion, demonstration and excursion methods have been followed. All these methods depend upon each other. No one method works in isolation. You must have noticed that a lot of preparation is needed to demonstrate or to organise an excursion. The teacher should be ready to answer any question and face even nasty situations. You should accept all criticism patiently and answer clearly. In demonstration or excursion, the students observe and analyse. They may put to you questions based on their observations.

Try to help them in analysing the data and arriving at conclusions.

Assignments

1. Arrange field trip to a veterinary college Acquaint yourself with the working there.
2. Prepare a list of veterinary colleges/hospitals.
3. Collect pictures of good breeds.
4. Practise how to select good breeds.
5. Prepare a chart showing the balanced diet of cow, hen, etc.
6. Make a model of chick brooder
7. Practise how to cull the birds.
8. Collect pictures of artificial insemination.
9. Collect the samples of roughages and concentrates and label them.
10. Make an album of draught animals, milche animals and meat giving livestock.
11. Collect the samples of different materials we get from animals and label them.
12. Analyse the contents.
13. Sequence and resequence your teaching strategy.
14. Compose your own notes on how to teach the concept.

15. Construct some questions to make the pupil think.
16. Practise feeding a calf
17. Make a model of cow shelter/bull shelter, etc.

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CHAPTER 14

Population Problems

Introduction

The explosive growth of human population is the most significant terrestrial event of this century. The growth of population was slow in the beginning, it was also delimited by many natural factors, but lately it has grown rapidly.

The concept of population as a controlled and regulated unit did not arise from the study of the animal and plant populations. Indeed, to regard groups of animals and plants as population is relatively a recent development. Instead, the population concept arose from man's desire to control his own numbers and to organise his own society. Plato (428-348 *B.C.*) described in his writings known as the *Laws* how he thought his society should be established and run. Similarly, Thomas Malthus, an Englishman presented a new and more scientific approach to population problems. Several questions constantly disturbed Malthus. Can man improve the kind of life he lives ? Must man always be subjected to wars, disease, poverty and to famine, or was it somehow possible for man to live a better kind of life ? Today many such questions are being posed and relevant answers have been sought to find out answers of the problems caused by population explosion.

Do you know the meaning of population explosion ? The sudden rise in the numbers of human population has created numerous problems which has compelled all nations to plan and control population growth. The purpose is to maintain human population within reasonable limits, because the resources on earth are limited and unprecedented growth will cause imbalances. These diminishing resources on earth are : food, fresh air, drinking water, living space, energy resources, etc.

Major Concepts

1. A population is a growth of orga-

nisms of the same species inhabiting a defined area.

2. The structure of population consists of the individual members and the way they are distributed in space.
3. A population regulates itself and adjusts, within limits, to a changing environment by renewal and replacement of individuals.
4. Rate of increase in population varies in the developed and developing countries.
5. Population increase in numbers requires sufficient physical environment upon which humanity depends for life.
6. Overpopulation has contributed in many ways to the general deterioration of physical environment.
7. Direct threats to human health are the most obvious aspects of environmental deterioration.
8. Pollutants due to over-industrialization reach human beings through air, water, food and sound. These pollutants are health hazards
9. Overpopulation and over-industrialization have created ecological imbalances and shortage of energy

Activities

Concepts of Population

You have come across many articles on population explosion in daily newspapers and journals. You shall also be reading about and realizing the shortage of resources needed for all of us. Did you ever try to relate population growth and shortage of resources ? You may read such articles and try to find out the relationship between population growth and diminishing resources.

Ask the students to study the populations of Australia and Britain. Let them compare the populations of these countries with that of India and China. Ask them a few questions such as . what major differences do they find ? Can they determine the causes of rapid population growth in India ? Can they determine population in various areas of the country ?

Ask the students to observe two insect boards where many insects have been preserved ; an aquarium where many fishes are kept ; a pond in your school where frogs inhabit and your classroom where your friends sit. Help them to draw conclusions from some such examples. You may help them infer that in such cases a group of individuals, identical with respect to kind and limited to a given space, have been mentioned in these examples. Can you draw a definition of population on the basis of these examples ? Let the students write the definition of population and check it with the textbook or any other book.

We have introduced this topic through self-study method where pupils learn and understand the concept of population. As a science teacher you can help them in searching similar examples or activities.

Concept of Population Explosion and Problems

You may introduce this concept by narrating an experiment on population of mice At the University of Wisconsin, John Emlen and his students studied the population of house mice in some old buildings. They provided 250 grams of food for the colony during each day of the experiment. The mice reproduced quite rapidly, and a larger and larger population developed. For a time, all the mice under study remained in the building As the population increased, however, shortage of food developed,

for the daily supply was kept constant When the number of mice became larger than the number that 250 grams of food per day could support, some mice left the colony. This experiment suggests that food can become a limiting factor to the increase of population in an experimental area.

You may plan similar experiments under the guidance of your teacher. This experiment should be on a small scale. Try to determine the causes of (*a*) food shortage, (*b*) space shortage, (*c*) effect on population growth if food supply is increased, (*d*) effect on population growth if food supply is decreased.

You are suggested to undertake a similar experiment on paramecium When paramecium grows in number there is struggle for survival among the members of the population Observe and record the events which happen in the experiment. Discuss with your friends and the teacher. These experiements should be taken as group activities. Do you find any relationship between population growth and the environment ?

Ask your pupils to grow some seeds (bean seeds grow quickly) in small pots. One group of pupils may grow three seeds in a pot, another 10 seeds, another 100 seeds. The shape and size of the pots should be the same. Ask them to observe if there are certain changes in overpopulated pots. You can modify this experiment by growing two, three, or more seeds at one locus and then help them to observe. Let them record their data in observational charts.

How will you guide them for this experiment regarding the size of the pot, light and water conditions, etc. ?

Take your students to nearby ponds. Do you have *Eichornia* (terror of Bengal) growing around ? Observe such a pond periodically. How fast this 'weed' is growing ? Help them to establish relationship of the growth of the weed, size of the pond, effects on the fishes and other plants. Also discuss how we can check the overpopulation of this weed.

Method Used

In teaching the concepts of population self-study method has been used. Here the student has been exposed to a wide range of references The attention of the student is also focussed on his day-to-day observations. By this the student learns himself and the teacher acts as a guide.

While teaching the concept of population and related problems an enquiry approach has been followed The students are motivated by narrating an experiment and based on this experiment various other activities have been suggested. The conclusion of the experiment is drawn through discussion.

What other methods do you propose to teach these concepts ?

Assignments

1. Organize a debate on population explosion in relation to country, and your own town.
2. Prepare charts showing differences of population growth in different countries.
3. Prepare charts to show the growth of population during the last ten years. Consult the Indian Year-Book and show the growth rate. Compare it with some other country.
4. Undertake a demographic study of population growth.
5. Conduct a case study of a developed and developing country. Determine the causes of population growth.
6. List the causes of poor standard of

living in India related to population.

7. Complete an assignment on population growth in the next decade, say, 1990 and its effects on living.

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CHAPTER 15

Food Adulteration

Introduction

Food adulteration is an antisocial practice and is a serious menace to public health. Specially, the growing children suffer most. It is commonly practised in India by dishonest traders, producers, wholesalers and retailers. They adulterate the food materials with rubbish and cheap materials. This is done to increase the quantity to substitute on subtract substances, which adversely affect the nature, substance and quality of food. This reduces the food materials in nutritive value Often the adulterants are injurious to health. A poisonous adulterant, when introduced into the body in sufficient quantity, is capable of injuring health and can even cause death. It is the awareness of common people that may prevent this serious health hazard due to adulterated food. In order to protect public health, the Government of India promulgated the *Prevention of Food Adulteration Act* (*P.F.A. Act*) in 1954. This act prohibits the manufacture and distribution of not only adulterated foods but also foods contaminated with toxicants and pests. School-education should, therefore, create among the children an awareness of food adulteration practices in the country, the common adulterants and their effect on health. Similarly, an awareness of the legal ways to punish the people who indulge in such social crimes has also been indicated. Students should also know the different types of adulterants in common use and the methods to detect them.

In teaching this unit the following major concepts are to be developed:

1. The main cause of food adulteration is scarcity of food due to overpopulation and natural calamities.
2. Adulteration of foodstuff is commonly practised in India by the traders.
3. Common food materials are adulterated with various kinds of foreign

substances and chemicals.

4. Some of the common adulterants in food are :
Chemicals (lead chromate, metanil yellow, artificial dye, mineral oil etc.), colour, water, metal, stone and other waste materials and various other matter of plant and animal origin such as : seed, leaf, bark, leather, fat, etc.
5. Contamination of food with harmful micro-organisms and pests during production, storage and handling is also a major source of adulteration.
6. Foodstuff may also be contaminated with toxic chemicals, such as pesticide and insecticide
7. Foodstuff is adulterated if certain valuable ingredients are subtracted from them.
8. Nutritive value of foodstuff is lowered by adulteration.
9. Use of prohibited preservative or permitted preservative in excess is also a kind of adulteration.
10. The quality and quantity of food fall far below the prescribed standard by the addition of adulterants.
11. Food-adulteration causes serious health hazards, viz.—gastro-intestinal disorder, respiratory disorder, stunted growth, dropsy, paralysis, cancer, mental retardation, vision defect, lathyrism, dermatitidis and even death
12. The national food standards are FPO Agmark, ISI, etc. The Indian Standards Institution (ISI) has been prescribing standards for various commodities.
13. Lack of strict enforcement of P.F.A. or punishment to dishonest producers (people) and retailers is one of the main factors responsible for food adulteration practices prevalent in the country.
14. The "International Codex Alimentarius Commission" is the principal organ of the worldwide food-standard programme.

Activities

Concept 3 : Common food materials are adulterated with various kinds of foreign substances and chemicals.

This concept can be developed through *enquiry approach* and *pupils' activities*.

It may be treated as an introductory concept. Enquire from the students their source and quality of milk supply. Record the data on the black board. Help the students to calculate the percentage of pure milk supply in the locality from their own sources of information.

Help them identify the unsatisfactory milk supply. Let them list out the reasons and the different types of adulterants in milk. Now you may demonstrate the use of a "Lactometer" to find out the specific gravity of pure milk and adulterated samples. Tabulate the findings on the B.B. Adopt question-answer method to bring out the concept of 'adulteration'.

A few developmental questions are given below :

What is the density of pure milk ?

How to find out whether the milk is pure or mixed with water ?

How to find out the amount of water added to the milk ?

This concept can be reinforced by employing group activity in the class on simple projects as :

(*a*) Collection of adulterated food samples from the local markets
(*b*) Observation and recording of data in Lab. note-book as suggested below.
(*c*) Presentation of data on B.B. for discussion.
Students group may be made on : milk, beverage, cereal, pulses and spices. Ask them to record results in the data sheet
The data sheet may be on the following lines :

Kind of food	*Source of supply*	*Common adulterants*	*Percentage of adulterants*	*Effect on health*	*Remarks*
1	2	3	4	5	6

After this you may ask a few model questions as given below :

(i) What are the different types of adulterants in rice, wheat, and pulses ?
(ii) How to remove them ?
(iii) What are mixed with mustard seeds for adulteration ?

Concept 4 : *Some of the common adulterants in food are chemicals (lead chromate, metanil yellow, artificial dye, mineral oil etc.), colour, water, metal, stone and other waste materials, and various other matter of plant and animal origin such as seed, leaf, bark, leather, fat, etc.*

Ask the students to collect cereal, pulses, 'haldi', ghee, butter, 'khoya', tea leaves, etc. You may first demonstrate various types of adulterants mixed in these materials. Next, design student activity. Ask the students to weigh the cereals and pulses Ask them to sort and sieve out the foreign materials. Let them find out the quantity of adulterants by weight. To find out the infected seeds, ask the students to put 100 seeds, selected at randam, in water. See how many of them are floating on the surface of water.

Count them. Help student in calculating the percentage of infected seeds :

Percentage of infected seeds

$$= \frac{\text{No. of infected seeds}}{\text{Total No. of seeds taken}} \times 100$$

Give them a small quantity of turmeric powder. Ask them to find out the adulterant. The general procedure of experiment to be followed is provided here. Take 2 gms of 'haldi' powder in a crucible. Heat till it becomes white ash (at high temp.) Cool and dissolve the ash in 5 ml of 1 : 7 dil. H_2SO_4. Filter it. Add few drops of 0.2% diphenyl carbanide A pink colouration indicates the presence of chromate. Help your students deduce that chromate is an adulterant in haldi. Similarly, let them

find out the adulterants in 'ghee'; steps to be observed are given below :

(*a*) Take 5 ml of 'ghee'.
(*b*) Add 0.1 gm of sucrose dissolved in 5 ml of dil. HCl.
(*c*) Shake the mixture well.
(*d*) Keep for 10 minutes.
(*e*) Permanent pink colour will indicate the presence of sesame oil.

Use butter and 'Khoya (evaporated milk) for starch-iodine test.

Perform filter paper test for artificial colouration of tea leaves. For further clarification you may refer to the book on Life Sciences—A Text Book for Secondary Schools (Classes IX-X), 1975, published by NCERT. Now ask the students :

What is the type of adulterant in 'haldi' powder ?
How would you detect the adulterant ?
Is it safe to buy powdered spices ?
How to find out the purity of 'ghee' ?
What are the types of adulterant mixed with 'ghee' ?
What tests would you perform to ascertain that the sample of 'khoya' is free from adulterants and the tea leaves are pure ?

It may be reinforced that even *the use of unpermitted colour and flavour is a type of adulteration*. For this you may demonstrate or give individual activity to the students

Ask the students to collect different types of candies, ice-creams and coloured drinks.

Dissolve sweets (ice-creams, chocolate etc.) in water, shake and transfer the water extract. Add dil. HCl to it. *A violet red* colouration will show the presence of *metanil yellow*.

Encourage the students to answer the questions .

'Pan'-shopkeepers or street vendors sell coloured drinks in bottles; should you drink them ?
What is the harm if you drink them ?
Why children should be discouraged to buy ice-cream from street vendors and candies of unknown brands ?
What colours are used to dye foodstuff ?
Are these artificial dyes harmless ?
How do you detect the presence of metanil yellow in foodstuff ?
In what ways the adulterants are harmful to us ?
What is your role in the [society to prevent adulteration of food ?

Assessment

In the Class :

1. Pupil's observations may be recorded on the lab-sheets and then on B.B.
2. The pupil should repeat at home some of the experiments demonstrated by the teacher in the class.
3. *Oral* questioning and tabulation of their own results on B.B. should be encouraged.
4. Written test, composed of 10-15 objective-based items on the topic, may be given.

Examples :

(*i*) Fill in the blank type ;
(*ii*) Multiple choice ;
(*iii*) True-false ;
(*iv*) Matching.

Test Materials

1. What is the meaning of food adulteration ?
2 List 3 adulterants in rice
3. Milk is adulterated by removing...

4 Milk is adulterated by adding ....
5. Starch powder is mixed to increase the weight of.............. ....
6. Bengal gram dal is often adulterated with............ ....
7. What are the symptoms of "Lathyrism" ?
8. Sometimes mustard seeds are adulterated with argemone seeds. What is the nature of disease caused if we consume mustard oil extracted from such a source ?

MATCH THE FOLLOWING

Adulterant	*Food stuff*	*Answer*
1. Papaya seeds	1. Curry powder	————————1.
2. Coloured starch	2. Rice	————————2.
3. Stones	3 Black pepper	————————3.
4. Water	4 Tea	————————4.
5. Dried small leaves	5. Coffee powder	————————5.
6. Tamarind seed powder	6 Milk	————————6.

Method Used

In teaching the topic enquiry approach through demonstration of experiment, discussion and student activity has been followed. Use of blackboard is of importance in analysing the data collected by the students through activity, demonstration, etc. Coloured chalks can be used to specify different types of data. Do you agree that a lot of preparation and/or planning is necessary before demonstrating an experiment ? What are the main considerations ? Size of the class, availability of apparatus and materials, improvisation of apparatus, use of simple household things in the absence of proper materials, procurement of chemicals in sufficient quantity and preparation of the list of requirements These are some of your considerations. You should yourself conduct the experiment prior to demonstration in the class Spare breakable glassware etc. should be kept at hand. Every aspect of the experiment, e.g use of chemicals and their specific reactions must be explained and discussed in the course of the demonstration. Questions should be put to the students related to their observations on the experiment. The aim always should be to make the class lively and active.

Select other topics where such demonstrations are possible. Based on the topic, prepare some instructional material for your self-study. List and emphasize in this material the different points and concepts for your own guidance.

If you are interested to know what is the "enquiry approach" to a topic, please see the chapter on 'Storage and Preservation of Food'.

Assignment (Home and Library)

1. Prepare a chart of different adulterants to common food and their

harmful effects on the humans and on animals.

2. Find out the meaning of ISI mark used in all the packets. What is the scope of PFA act ?
3. How can you check adulteration of food ?

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CHAPTER 16

Storage and Preservation of Food Materials

Introduction

There is acute shortage of food in our country Population is increasing day by day. Cultivable land is also being used for urbanisation so we have to think of various measures to grow more food. Over and above, the storage and preservation of food materials are also very important problems because due to lack of proper knowledge of storage about 10% of total food is wasted, which is quite a large amount for our country. The spoiling of food in storage may be caused by microbes, rodents, insects, etc. Micro-organisms are omnipresent. Like all other living organisms they also need carbon, nitrogen, vitamin and minerals as food for their growth. Suitable temperature, water and oxygen are also required. Our food materials, both raw and cooked, are composed of protein, carbohydrate, fat, vitamin and minerals. All of these, therefore serve as growth substrates for micro-organisms. Food spoilage is due to contamination of foodstuff with various microbes. While growing on them, they bring about chemical changes in the foodstuff, secrete metabolic by-products and cause spoilage. Methods of food preservation employ physical as well as chemical processes. In this chapter, as guidelines to the teachers, some illustrations are given about the different ways of food preservation against contamination by microbes. The concepts have been elaborated and enrichment activities, both for the pupil-teacher and students, have been suggested. The main sources of contamination are air, water, and soil. Our whole body, hand, mouth, skin, hair, etc. also carry a large number of microbes and can serve as contaminating sources.

Food materials are also spoiled by insects (ant, fly, cockroach, etc.) and rodents. The teachers should take them into account while teaching, in the manner suggested for micro-organisms. In teaching storage and

preservation of food the following concepts are to be developed :

Major Concepts

1. Micro-organisms are responsible for the spoilage of food-materials.
2. All the methods of food preservation are based upon one or more of the following principles :
   (i) Prevention or removal of contamination ;
   (ii) Inhibition of microbial growth and metabolism (microstatic action), and
   (iii) Killing of micro-organisms (Microcidal action).
3. One of the main factors for food spoilage is the high moisture content of food-stuff.
4. Microbial activities are arrested by certain preventive measures like dehydration, heating, cooling, freezing and other similar methods.
5. Drying is one of the easy ways to preserve food. Drying food in the sun is one of the earliest natural and economical ways.
6. Food is also dehydrated by various artificial means.
7. Nutritive value of food during drying is not much affected.
8. To preserve food-materials, contaminating micro-organisms are killed by physical (heat, pressure) and chemical means.
9. Food may be preserved by adding simple chemical substances (salt, sugar) or preservatives (vinegar, citric acid, sodium benzoate, potassium metabisulphite).
10. Canning, freezing and irradiation are modern measures of food preservation by physical means.
11. Microbes are microscopic organisms.

Activities

Concept 1 : Micro-organisms are responsible for the spoilage of food materials.

This concept can be developed as the introductory topic. Students can be motivated by choosing "pickle" as an example. Concept numbers 1, 2, 3, 4, 5, and 10 can be covered through this example. Only proper planning of teaching methodology is required.
All the children are fond of pickles. So ask them few questions to measure their power of observation in relation to pickle making :

How pickles are made at home ?
What precautions do mother and grandmother take in making them ?
What happens if pickles are touched with hand ?
Analyse why it is called "ACHAR "

Concept 5 : Drying is one of the easy ways to preserve food. Drying food in the sun is one of the earliest natural and economical ways.

Discuss with students the different steps in pickle making :

The first step is to dry the fresh fruits, vegetables etc in the sun. This is to remove their excess water content. Water is essential for microbial growth. Drying in sun has double effect (1) When excess water is removed the cell sap gets concentrated and the osmotic pressure rises. Micro-organisms have difficulty in growing under such condition. (2) Sun's rays (ultraviolet) have germicidal properties, hence many microbes are killed. During drying the pickling stuff

is mixed with excess of salt and turmeric powder and kept in clean new earthenware vessels in a clean place.

Discuss with the students why salt, turmeric powder, new and clean earthenware vessels, etc. are used in making pickles Salt, a household chemical, is used to kill microbes.

Microbes suffer from exosmosis and die on surface of the pickled fruits/vegetables as they come in contact with excess salt. Thick sugar solution also causes exosmosis in microbes.

Turmeric powder and vegetable oils have micro-static properties. Thus we see salt, sugar, turmeric powder, oil, all act as preservatives. The whole principle of food preservation can be taught well through this example.

Now ask the students :

What happens if pickles are not kept in the sun frequently ?
Why are they kept in the sun ?
In what season do pickles go bad ?
Explain why

Concept 2 : *All the methods of food preservation are based upon one or more principles.*

The students should be told that foodstuff preserved through different methods stay longer for consumption.

All the methods are based on one or more principles.

The various principles involved are :

1. Prevention or removal of contamination.
2. Inhibition of microbial growth and metabolism (microstatic action) and
3. Killing of micro-organisms (microcidal action) For understanding these principles the following activities have been designed.

Make two groups of students Ask one group to collect fresh milk, fresh fruit, vegetables, meat, fish, bread slices, rice, wheat, gram, dal, sugar solution (*dil*) Let these be kept in the classroom, unprotected for 3-4 days. Similarly, ask the second group to collect :

(i) Pickles, 'Amchur', 'Murabba' and 'Ampapad'.
(ii) Thick evaporated sweetened milk or 'Khoya', 'Peda' and dry powdered milk.
(iii) Dry fruits, potato tuber, garlic and onion bulbs etc.
(iv) Well-fried fish and toasted bread. Keep them inside any meatsafe for the same time period (3-4 days).
(v) Canned fruit, jam and jelly in bottles
(vi) Frozen fruit juice, meat, fish kept in refrigerator. Allow them to remain there for 3-4 days.

After 3-4 days ask the students to note down their observations. Help them to analyse and compare the observations from the two sets of experiments on the B.B. Try to bring out the truth and the concepts involved.

Ask them to categorize the types of food loss and spoilage observed. Finally, make the students realise the necessity of food preservation. After the activity and experimentation students should be encouraged, through enquiry approach, to analyse the result on blackboard and draw inference.

Here you can narrate different modern methods of food preservation viz, canning, freezing etc The microbes need an optimum temperature for normal growth. Optimum temperature varies with the kind of microbes. But most of the living things cannot grow at boiling (100°C) or freezing (0 0°C) temperature Living things also require oxygen for respiration and hence can not grow in vacuum. These characteristics of microbes have been made use of in preservation techniques like canning or freezing. During canning, the temperature of the foodstuff is raised to boiling point for several minutes and then vacuum sealed.

Concept Nos. 8, 9, 10 are involved in the activity. The following questions, framed on the above activity, may be asked next :

Which kind of foodstuff were spoiled ?
What are the different types of spoilage observed ?
What kind of foodstuff got spoiled sooner ?
Why do they get spoilt soon ?
What factors are responsible for their spoilage ?
Why people generally drink boiled water during the rainy season ?
How has it become possible to get non-seasonal fruits ?
How are perishable foodstuff transported from one corner of the country to another ?

Now look at the sugar solution, milk, fish and meat.

What kind of physical and chemical changes do you observe in them ?
How does the sweet sugar solution taste after 4 days ?
Frothing on the sugar solution is due to what reason ?
What changes do you see in fresh milk ?
How does it smell ?
Do you see any change in colour ?
Why should one take 'boiled' milk ?

Next observe bread slices, fruits and vegetables

What are growing on them ?
What are their various colours due to ?
How does the foodstuff smell ?
Describe the various coloured zones on them.

Now look at the pickles, 'amchur', 'khoya', 'murabba', 'ampapad', 'toasted' bread slices, fried fish, canned and frozen foodstuff

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Which kind of food did not get spoiled ?
What could be the reasons ?
Why should cooked food be kept clean inside the meatsafe ?
Do you observe any chemical and physical change in these foodstuff ?
Why 'Amchur' is salted and 'Murabba' sweetened to preserve ?
What part do salt and sugar play there ?
Why does the bottled ketchup stay longer than homemade tomato soup ?

Concept No. 11. Microbes are microscopic organisms.

Microbes are very small organisms which can be seen only through hand lense/ microscope This topic can be taught by narration followed by demonstration of stained slides of fungi and bacteria. If microscope is not available then blackboard work should be done. After acquainting the students with microbes you may give an activity in the laboratory. This activity may be completed in 3 lab. sessions of 40

minutes each. The break-up of the work period-wise is :

(i) Preparatory stage
(ii) Actual working (experimentation)
(iii) Discussion and conclusion.

Instructional Objectives

The pupil will be able to :

(i) acquire knowledge about microbes that spoil common foods we use.
(ii) understand that moisture is one of the essential factors for growth of microbes.
(iii) apply the knowledge gained in storing and preserving the daily useable foods.

The approach suggested is laboratory-oriented *enquiry model.*

During the first period you may make a list of materials required for the experiment. Try to collect the necessary materials with the help of students. Make small groups of students keeping in view the size of the class. Distribute the materials to each group The list of materials is given below. This will be the preparatory stage.

Materials Required

1. Bread pieces (toasted and fresh)
2. Cut-potatoes & other vegetables
3. Citrus, apple or any other fruit
4. Milk (fresh)
5. Cellophane bags
6. Microscope/lense
7 Slides and cover glasses

In the second period demonstration followed by experimentation can be taken up. Assign the work group-wise and allot them place to work. Give both oral and blackboard instructions.

To one student give a piece of bread moistened with a few drops of water and to another give a dry toasted piece. Ask to keep them separately in cellophane bags with date and time of experiment written on them. Experiments should be labelled :

'E' as experimental and
'C' as control The first one is experimental here.

A similar set may be kept with a cut potato (experimental) and a whole one (control) Both should be kept separately in cellophane bags.

Ask the students to record their observations consecutively for 3 days.

Discussion and Conclusion

After three days students' data must be put on the blackboard for discussion through enquiry approach as suggested below :

Expected Learning Outcomes

The pupil will be able to :

(i) *Readily Observe* spoilage in moist bread and cut potatoes.
(ii) *Identify* that the spoilage is due to microbes.
(iii) *Identify* that the slimy growth on the cut potato is due to bacteria. The wooly white and coloured patches on the moist bread are moulds.
(iv) *Observe*, there is hardly any such growth on the dry toasted bread and the whole potato (control).

Discussion to be generated about the importance of having a 'control' in the experiment.

Sequential Learning activities

Demonstration discussion :

Teacher will exhibit the spoiled food and slides of microbes prepared from these items. Generate discussion by asking *simple lead questions*.

Showing the specimens ask

What difference do you observe in the bags labelled, "experimental" and "control ?"
What is the reason for the different colours on the spoilt pieces ?
What are present in the black brown spots ?
How will you prove that microbes are responsible for spoilage of food-stuff ?
Which of the foods got spoiled soon ?
During the hot summers, why milk gets sour in 4 hrs. if it is not boiled ?

Like this, the pupil-teacher will have made detailed planning in the beginning of his/her practice. (Brief lesson plans/self-study materials should be encouraged if one has learnt the skill of planning-properly).

Assessment

1. Pupils' observations be recorded on the lab-sheets and then on B B.
2. The pupil should repeat at home some of the experiments, demonstrated by the teachers in the class.
3. Oral questioning and tabulation of their own data on B.B should be encouraged.
4. Written test composed of 10-15 objective-based items on the topic be given

Examples

(i) Fill in the blanks type ;
(ii) Multiple choice ;
(iii) True-false ,
(iv) Matching.

Test materials

1. What are the most common reasons for food spoilage ?
2. What do you understand by food spoilage ?
3. Micro-organisms are responsible for ————————of fruits.
4. Souring of milk is due to the activity of————————.
5. The three important methods used in food preservations are :
   (*i*) ——————————.
   (*ii*) ——————————.
   (*iii*) ——————————.
6. Bottled milk is————————before marketing.
7. Salt is used as————————in pickling.
8. Why fried fishes stay longer ?
9. Why food stored in refrigerators does not get spoiled soon. Give two reasons.
10. Name three microbes which are responsible for spoilage of fruits in storage.

Method used

In teaching this topic, what methods have been suggested ? Do you feel this can be taught effectively through other methods ? The possible methods are : demonstration of experiments, actual experimentation through students activities, demonstration-cum-discussion etc. In the context of the learning outcome of the students, examine the relative place of each method Before designing an experiment for demonstration what should you consider ? Availability of apparatus and materials, visibility to all students, improvisation or anything else ?

Active participation by students during any kind of demonstration/experimentation is always recommended. Never allow the students to be *passive listeners* in the class. Generate activity by getting their own observations in the class experiments. Also ask them about their day-to-day observations in the environment related to the topic As home task ask them to prepare different types of lists related to the topic. Ask them to collect various kinds of information, group-wise Encourage and satisfy them by discussing these in the class. Also try to bring out their own concepts regarding the topic. Develop through their active participation the new concept you want to give

Think of other subject matters and topics which can be taught through such methods.

A word or two on the 'enquiry approach.' In this chapter this approach has been used to introduce the topic to the students. The students get motivated when they are asked to enquire about the cause of certain daily phenomena occurring around them. Their answers, right or wrong, should be encouraged. Call students one by one at random and ask them to put down their answers on B.B. When sufficient answers, to a particular question, have come from the students, start analysing them one by one. Score out the wrong answers and highlight the right ones. This approach gives the students chance and motivation to think, enquire and analyse. This will increase their inquisitiveness regarding things around them. They will also start having an analytical mind This kind of training is necessary for the budding scientists.

Likewise, observations from laboratory experiments should be discussed in the class through the enquiry approach This method helps to increase the horizon of students' knowledge.

Assignments

(In the library/at home)

1. List several types of microbial food spoilage. Collect names of the organisms responsible in each case.
2. Mention the principles of food preservation.
3. List names of pests and insects that spoil food during storage.
4. Prepare a chart with names and diagrams of micro-organisms responsible for common food spoilage. Against each name list the types of spoilage.
5. List down the most common methods, used at your home for preservation of various foodstuff.
6. Make a list of common mistakes, committed at home, which cause food spoilage.
7. Write various expected learning outcomes of the topic.
8 Sequence and resquence your lesson plan
9. Describe how you will plan a visit to a cold storage or a dairy farm ?

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CHAPTER 17

Mole Concept

Introduction

The basic relationship among chemical quantities involves relative number of atoms, ions or molecules not masses or weights, etc. For example, if we compare the amount of heat liberated by different chemical reactions, our comparison will have more meaning when the heat is measured for reactions in which the same number of atoms, molecules or ions react. Although we recognize the importance of relative numbers of chemical units (atoms and molecules), still there is no way by which we may count them in the literal sense. Atomic weights and formula weights are chemical terms denoting mass. Thus, we need to establish a relationship between the measured mass of an element and some known but uncountable number of atoms. The number that proves most useful is the number of atoms present in 12 00000 grams of $^{12}_{6}C$. It has been determined that this 12.00000 grams of $^{12}_{6}C$ contains 6.0225×10^{23} atoms This number (which has the value of 6.0225×10^{23}) is called Avogadro number[1] (after the name of the scientist who first proposed the principle upon which it is based) or *mole* In the present unit, you will learn of developing *mole concept* in chemical stoichiometry[2].

Major Objectives

1. To develop the mole concept—mole as a number (i.e. mole is a quantity which directly depends on the number of atoms or molecules rather than on their masses).

2. To acquaint the students that mole concept is useful in describing stoichiometry of a chemical reaction (application of mole concept).

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1 The latest experimental value for the Avogadro number is $6.02252\ (\pm 0\ 00028) \times 10^{23}$ In simple calculations it is taken as 6.02×10^{23}

2 That aspect of chemistry which deals with mass relationship in a chemical reaction is called stoichiometry

Concepts

(i) Mole is a number equal to 6.0225×10^{23}.

(ii) Mole is a unit for expressing the amount of a substance.

Skills

After learning the mole concept, students will develop an ability to perform stoichiometric calculation successfully.

(a) Given the mass of a substance—students will be able to calculate the number of moles, number of molecules or atoms present in the substance and vice-versa.

(b) With the help of chemical formula, students will be able to calculate the moles of each constituent present and the ratio by mass and vice-versa.

Development of Concept Through Activities

(A) *Experiment 1* : Weigh 0 5 g of zinc dust and 0.5 g of iodine and transfer both of them in a boiling tube and add[1] a few drops of water. Ask your pupils to observe carefully. Are zinc and iodine fully utilized during the reaction ? Wait for a few minutes and then add 15 cm^3 of water. Shake the test tube well and keep for one minute. Add 2 cm^3 of ethyl alcohol. What do you see ? Iodine is fully utilized (since no colour is obtained by adding alcohol in the test tube) and a small amount of zinc settles in the bottom of the test tube.

Experiment 2 : Weigh 1 g of iron powder and 1 g of sulphur powder. Mix them properly and transfer in a test tube. Heat the mixture over the flame for about 5 to 10 minutes till you are sure that there is no further reaction and mixture becomes a hard solid mass Cool the test tube and break it to take out the solid mass. Break the mass into small pieces and ask your pupils to see with the help of a magnifying glass. What do they find ? Now bring a magnet over the broken solid pieces Does the magnet attract the pieces thus obtained ? You will find that iron is no more in the mixture whereas yellowish particles of sulphur are still there left unreacted.

Discussion

The question now arises why zinc in experiment 1 and sulphur in experiment 2 are left unreacted though you had taken equal mass of zinc and iodine for experiment 1 and equal mass of iron and sulphur for experiment 2. It means that taking equal mass of reactants for their being fully utilized in a reaction is not the criterion.

Now let us write both the reactions in the form of an equation :

$$Zn + I_2 \rightarrow ZnI_2 \quad \text{... (i)}$$

$$Fe + S \rightarrow FeS \quad \text{... (ii)}$$

From the above equations we see that 1 atom of zinc should react with 2 atoms of iodine and form one molecule of zinc iodine Similarly 1 atom of iron should react with 1 atom of sulphur and form 1 molecule of FeS. Here in experiment 1, iodine does not provide the requisite number of iodine atom for complete consumption of zinc when we take equal mass of zinc and iodine. Also iron does not provide the same number of atoms as are in sulphur in experiment 2 and consequently

1. After the water is added, reaction vigorously starts and therefore precaution should be taken in performing this reaction.

sulphur is left unreacted. What is the important conclusion pupils draw out of the above two experiments? They will come to know that it is the number of atoms present in a mass which is important not the mass itself.

(B) Importance of number can be further illustrated by taking an analogy. Take equal masses of two elements A and B into two beakers. Suppose equal masses of A and B contain 15 and 9 atoms respectively. Consider these atoms in the form of polystyrene balls (an analogy) of different sizes as shown in figure below :

have to find out a relationship between the number of atoms and mass containing these atoms After knowing the relationship only you can weigh mass of a substance containing a definite number of atoms or molecules.

If polystyrene balls of different sizes are not available make use of pea and glass balls for denoting atoms of A and B respectively or choose any other suitable grains.

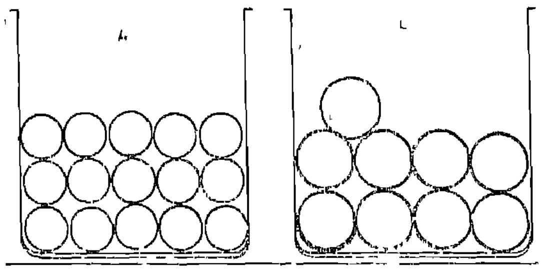


Fig. 17.1 An analogy for explaining importance of number

If one atom of A combines with one atom of B you will get 1 molecule of AB. If you consider the reaction in steps you will get the following nine steps :

(1)	oO	(6)	oO
(2)	oO	(7)	oO
(3)	oO	(8)	oO
(4)	oO	(9)	oO
(5)	oO		

At the end of the reaction all the atoms of B are consumed and 6 atoms of A are left unreacted. Now if you are in a position to take a certain mass of A and a certain mass of B providing equal number of their atoms, A and B will be fully utilized at the end of the reaction. In other words, you

(C) You also must be familiar that while comparing the masses of different atoms to get *relative atomic masses*, we take a certain *number* of atoms of one element and compare with the same *number* of atoms of the second element. While doing so, we further realize the importance of number in Chemistry.

By this time your pupils are convinced that it is the number which is important in chemical reactions. Now take an analogy related to daily life situation. In our daily life situation even there are many instances where we talk only of number not of weight. For example, in the market place while purchasing eggs, bananas, etc., we usually purchase in number and it is convenient to

talk of cost per dozen While purchasing paper we talk of cost of paper per ream.

Chemists realized the *importance of number* in stoichiometry. Molecules, atoms and ions being extremely small in size cannot be considered in terms of dozen, hundreds, etc. Chemists had to select much bigger number of atoms or molecules which gives a mass worth weighing. No doubt, they could find out the number known as Avogadro's number or mole. The latest experimental value of mole is 6.02252 $(\pm 0.00028)\times 10^{23}$. Mole is defined as the number of atoms in 0 012 kg of $^{12}_{6}C$ Thus similar to dozen (12 items), scores (20 items), gross (144 items or twelve dozen items), *mole is a number* We can think of one mole of atoms, molecules, pens, tennis balls, chairs, people, etc.

(D) Mole as a unit for amount of a substance

Before talking of the amount of a substance, let the students recall various physical quantities.

Amount of a substance is regarded as a physical quantity like length, time, mass, etc. Each physical quantity is measured in terms of a particular unit, e.g., length is measured in 'metres', time is measured in 'seconds', mass in 'kilograms'. Similarly amount of a substance is measured in terms of 'moles'. SI Unit for *amount of a substance*[1] is mole abbreviating as 'mol'. Comparing the amount of substances, chemists want to compare equal number of particles

Thus equal amount of substances are chosen to contain equal number of moles. For example, if we talk of 1 mole of sodium and 1 mole of silver, in chemical sense, we will say that the amount of sodium and silver is the same, i.e. in both the cases there are equal number of particles (atoms). Similarly 1 mole of CO_2 contains the same number of molecules as 1 mole of H_2O.

A mole of a substance is an amount of substance that contains the same number of elementary Unit as there are $^{12}_{6}C$ atoms in 0.012 kg of $^{12}_{6}C$.

Using mole (Background Material)

(Take up this portion only, when you are sure that pupils are clear about 'mole' as a number In this section pupils will come across various activities like comparison, manipulation, finding mole as a conversion factor and problem-solving. Several aspects deal with higher knowledge therefore those may be taken in details in other unit coming subsequently).

(A) The weight of one mole atoms in grams will be gram atomic weight or *gram atom*. The weight of one mole molecule in grams will be "gram molecular weight[2]" or '*gram mole*'. Let us take specific examples :

(*i*) A mole of water $(6.02\times 10^{23}$ water molecules) weigh 18 grams.

1 While refering to the amount of a substance, we always mention items—like atom, molecule, etc. But suppose there is no such mention and it is only *1 mole of that substance*, in that case, we should take the standard form of the substance i.e form in which the substance exists For example, one mole of water means one mole molecule of water or 1 mole sodium means one mole of sodium atom, etc

2. Now a days in place of saying 'molecular weight' it is called 'molecular mass'.

(ii) A mole of hydrogen gas will contain 6.02×10^{23} hydrogen molecules and being diatomic will have $2 \times 6.02 \times 10^{23}$ atoms and will weigh 2.016 grams.

(Taking many more such examples explain to your pupils the meaning of gram atomic weights and gram molecular weights).

(B) For molecular substances (e g. CO_2, H_2O, NH_3, etc) one mole and one gram molecular weight weigh the same and represent the same number of particles, 6.02×10^{23}. But what about ionic substances like NaCl, $AgNO_3$, etc. 'NaCl' is not a molecular formula and as such does not represent a molecule of sodium chloride Will it be correct to say gram molecular weight of NaCl ? In fact, entire crystal of sodium chloride may be considered as a '*giant molecule*' and it will be misleading to refer to gram molecular weight. However, we can say one mole of NaCl and it refers to a specific mass 58.44 g (which is also given the name 'formula weight'). One mole of NaCl will contain :

(a) one mole of sodium ion, i.e. 6.02×10^{23} Na^+ and

(b) one mole of chloride ions, i.e. 6.02×10^{23} Cl^-

(Emphasise the point how mole concept could be helpful in specifying the amount of ionic substances. Before this, pupils should be aware of ionic and covalent (compounds).

---

(1) How many moles of atoms of hydrogen, sulphur and oxygen are present in 2 moles of H_2SO_4 ?

(2) How many moles of ions of sodium, aluminium, nitrate and sulphate are present in the following compounds ? Na_2SO_4, $Al(NO_3)_3$, $Al_2(SO_4)_3$, $NaNO_3$

(3) How many moles of hydrogen are present in two moles of the following compounds :

H_2SO_4, HCl, H_3PO_4.

(C) In normal practice as you might have seen a definite number of moles is taken by weighing. This is possible because there exists a relationship between the number of moles and the mass of a substance.

$$\text{Number of moles of a substance} = \frac{\text{mass of a substance (g)}}{\text{mass of one mole of the substance (g/mol)}}$$

Mole as a common denominator links various items like gram atom, gram ion, gram molecule, gram equivalent, Faraday, etc. In the stoichiometric equation, $A+B \rightarrow AB$, one mole of A and one mole of B can be linked with other terms in the following manner.

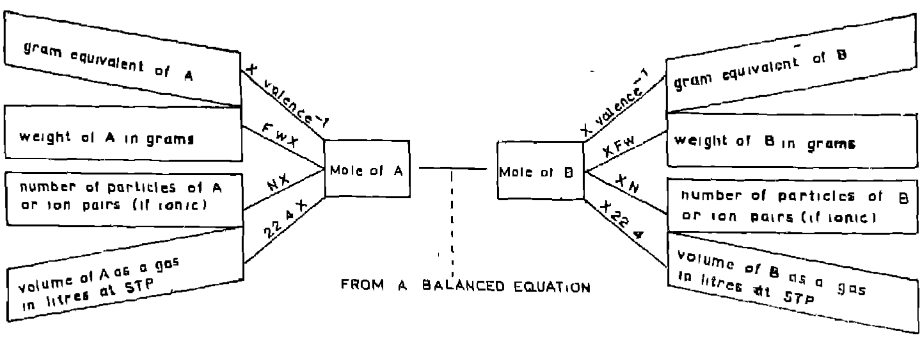
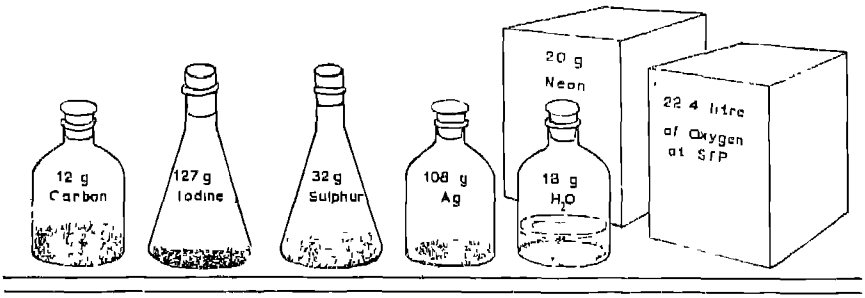


Fig. 17.2. Mole as a common denominator

(D)

(a) One mole of different substances does not have the same mass.
(b) Equal mass of different substances* will not give the same mole.

Develop the above ideas taking suitable examples as cited below :



What do each of these samples have in common ?

(E) Irrespective of the sizes of the molecules, 22.4 litre of any gas at STP contains 6.02×10^{23} molecules or 1 mole molecules If we know the volume of a gas at STP, it is possible to calculate the number of moles present. (*Discuss this part in detail while taking kinetic model of gases*).

(F) The quantity of electricity required to deposit one gram atom or one mole of silver from a solution of its salt is one Faraday Then, if we pass 1 mole of electron in the circuit $6\ 02\times10^{23}$ ions or 1 mole ions of silver, which are univalent, will be deposited.

$Ag^+ (aq) + e^- \longrightarrow Ag(s)$

1 mole 1 mole 1 mole (or 108 g of silver)

If we pass 2 moles of electrons or 2 Faraday of electricity, 2 moles of Ag^+ and one mole of Cu^{2+} (being divalent) from their respective solutions will be deposited.

(G) A numerical problem is given below to elucidate the method of approach in problem solving Your pupils will follow the same for solving their own problems in a class.

Problems

What mass of copper sulphate pentahydrate would correspond to 2.50 moles of $CuSO_4.5H_2O$.

Solution

Break the problem in the following steps

1. To determine mass of 2.50 moles of $CuSO_4.5H_2O$ in grams.
2. Given : 2 5 moles of $CuSO_4.5H_2O$
3. Information to be collected from the data book :

* In case of isomer the statement will not be quite valid e g. CH_3OCH_3 and C_2H_5OH are different substances and have the same molecular mass. 46 grams of CH_3OCH_3 and C_2H_5OH will contain equal number of mole i.e. 1.

Atomic mass of S $=32.05$ amu
Cu$=63.55$ amu
O $=16.00$ amu
H $=1.008$ amu

Thus, formula weight of $CuSO_4 \cdot 5H_2O$,

$$
\begin{aligned}
Cu &: (1 \times 63.55) = 63.55 \\
S &: (1 \times 32.06) = 32.06 \\
4O &: (4 \times 16.00) = 64.00 \\
(H_2O)_5 = \left\{ \begin{array}{l} (H_2)_5 \\ (O)_5 \end{array} \right. & \begin{array}{l} (10 \times 1.008) = 10.08 \\ (5 \times 16.00) = 80.00 \end{array} \\
& \overline{\quad 249.69 \quad}
\end{aligned}
$$

4. *Method of attack*

After getting the formula weight of $CuSO_4 \cdot 5H_2O$, we can relate the mass = no. of mole × mass of one mole of copper sulphate pentahydrate.

5. *Manipulation*

Converting mole into grams
1 mole of $CuSO_4 \cdot 5H_2O$ weighs 249.69 g
Therefore, 2.5 mole of $CuSO_4 \cdot 5H_2O$ will

$$\text{weigh} = \frac{249.69 \text{ g} \times 2.5 \text{ mole}}{1 \text{ mole}}$$

$= 624.23$ g

Mole concept to be revisited

You will come across 'mole concept' once again in detail in the units of 'Kinetic theory of gases' and Electrolysis' as mentioned earlier.

1 How much will 12.04×10^{23} atoms of carbon weigh ?

2 Determine the mass in grams of 5.20 moles of baking soda, $NaHCO_3$.

3. One drop of sea water contains fifty billion (50×10^9) gold atoms. Calculate the number of moles of gold in one drop of sea water.

Method Used

What method will you adopt in teaching this chapter ? The present chapter is developed mainly taking activities, like demonstration of basic ideas, collection of various samples, weighing and calculating the number of particles present in a definite mass of a substance. Being a typical chapter where major emphasis is laid on the number, various analogies are recommended to illustrate the idea. For example, for illustrating the idea of 'mole' as a number one can think of dozen, scores, etc. (taking suitable analogy from the surroundings) Analogy will be effective only when you select the objectives/ideas with which students are familiar.

In the present Chapter, you have seen that demonstrations are not only important for clarifying the concept but also for initiating the discussion in order to reach a particular conclusion. While carrying out the selected demonstration keep the following questions in mind :

1. What is the specific objective for demonstration ?
2. Why is it selected for demonstration ?
3. What is the *basic* idea we aim to teach ?
4. What are the crucial observations ?
5. How to improve the demonstration (design, etc.) ?
6. What are the special features of the observations which focus the interest of the students ?
7. What are the possible drawbacks of the demonstration ?
8. How can the students be involved mentally in the demonstrations ?
9. How long will demonstration take ?

10 What are the students supposed to do finally after taking the observation ?

For the better understanding of a concept or its application, or for determining various unknown physical quantities using known parameters, numerical problems should be solved. For this, train the students to solve the numerical problems on the pattern of *problem solving approach* as indicated in the main body of the Chapter For other Chapters also all the numerical problems should be done adopting this approach only.

Assignments

1. You are provided with

(*a*) 1 mole of hydrogen molecule
(*b*) 1 mole of ammonia molecule
(*c*) 1 mole of water molecule

Find out which one of the above substances contains the largest number of atoms and find out the number of atoms of each kind in these three cases.

2. Comparing the properties of similar number of particles gives an insight into the nature of the phenomena. Atomic heats of a few metals are given below. Plot a curve with the data given and find out the patterns which emerges.

Elements	*At Number*	*Atomic heat ($kJ\ mol^{-1}$ per kelvin) at 298 K*
Li	3	0.0235
Na	11	0 0284
Ca	20	0 0262
Zn	30	0.0251
Sr	38	0 0249

3 You are provided with 3 measuring flasks of 100 cm^3 capacity filled with following substances .

(*a*) H_2O
(*b*) CCl_4
(*c*) H_2SO_4

Note down the density of the above substances at room temperature (25°C) from a data book and calculate the number of moles contained in each flask Label the flask with the following informations.

Formula=
Formula weight=
Volume=
Density=
No. of moles=

4. A molar solution is prepared by dissolving *one mole* of a substance in sufficient solvent to make *one litre of solution.* What quantity of the following substances will be required to prepare 0.5M solution ?
$BaCl_2$, $NaOH$, $H_2C_2O_4.2H_2O$, $CuSO_4.5H_2O$

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CHAPTER 18

Model for an Atom

Introduction

Chemistry deals with varieties of matter. From Dalton's atomic theory we know that atoms of one kind behave differently when compared to the other For example, sodium is kept in kerosene and in fact never in water whereas phosphorus is preserved in water. Why do atoms of different kinds behave differently? The answer of this question perhaps lies in the structure the atoms possess.

In your house or while walking across the road you could have come across the neon lamp and fluorescent tubes. Have you ever thought why the glow produced in the two tubes is different in colour ? You *would have studied a lot of chemistry* and would have come to know that atoms combine to form molecules. Do you know why atoms behave in this manner ? In order to explore the answers for the querries raised above, a detailed study of structure of atom becomes essential.

Major Objectives

Students will be able to :

1. List fundamental particles present in an atom.
2. Differentiate between these fundamental particles.
3. Describe various models of atoms based upon experimental observations.
4. Interpret spectra on the basis of transition of electrons from one energy state to the other.
5. Define Heisenberg's uncertainty principle.
6. Appreciate the introduction of four quantum numbers to define the energy state of an electron in an atom.
7. Draw schematic diagram for the filling up of electrons as per their energy levels.

Concepts

1. Matter is electrical in nature.
2. Atom is composed of electrons, protons and neutrons.
3. Arrangement of electrons, protons and neutrons in an atom is explained by a number of models such as the *Thomson* and Rutherford model.
4. Radiant energy is emitted or absorbed in terms of discrete units called quantum.
5. Transference of electrons from higher energy level to lower energy level results into emission of spectral lines.
6. An electron exhibits both wave and particle nature.
7. The position and momentum of an electron cannot be determined simultaneously.
8. The region around the nucleus, where there is maximum probability of finding the electron, is called an orbital.
9. Electron within an atom may be designated by four quantum numbers.
10. Electrons are filled in various orbitals in order of increasing energy.

Skills

1. Suggesting models
2. Correlating the study with simple naturally occurring phenomena.

Development of Concept Through Activities

Concept · *Matter is electrical in nature*

Take a baloon and fill it with air bllown through your mouth. Now rub the balloon with your coat, silken or terylene shirt. Bring it near the wall. It is attracted by the wall. Now let us extend this activity further. Take two balloons and fill air in both. Suspend these with the help of thread. Bring the two balloons nearer to each other You will notice that the balloons can get close to each other (why ?). Rub the two balloons with your coat, silken or terylene shirt. Suspend them and again bring them nearer to each other. The balloons move apart. Why do they repel each other ? Have you ever noticed this phenomenon in your daily life ? A few such examples are given below :

1. As you take out your silken or terylene shirt from your body the hair of your arm get erected because of repulsion.
2. When you comb your hair while they are dry, they also get erected because of repulsion.

This property of attraction and repulsion results on account of electrical charge present in matter. Since coat, silken shirt, terylene shirt, wall, balloons, comb and hair are different varieties of matter, you have reason to believe that matter is electrical in nature.

Could you guess what different types of charges are associated with matter ?

Concept 2 · Atom is composed of electrons, protons and neutrons

In the activity discussed above you have experienced that matter is electrical in nature You have studies electrical discharge through gases. Before proceeding further you must answer the following queries which will help you in generalizing the fact that atoms are composed of electrons, protons and neutrons.

What types of charges are associated with matter ?
How are the electrons emitted in radio valve ?
Why do only certain radiations when interact with the metal surface, produce electrons and not all ?
Why the e/m ratio for the positive particle in the case of hydrogen is found to be the highest ?
What relationship does exist between the number of negative and positive particles in an atom ?

Concept 3—Model for an atom—arrangement of electrons, protons and neutrons in an atom.

This concept is being taken as an illustration as to how you will teach this concept in the class. On the basis of our knowledge that atom is electrically neutral following models may be proposed, to account for the arrangement of electrons and protons in an atom :

At this stage you will inform pupils about the Rutherford experiment The Rutherford experiment involved bombardment of thin gold foil by α-particles* The α-particles needed for the purpose were obtained from the radioactive element, radium enclosed in a cavity made on a lead block. To detect the α-particles coming out of the gold foil, Rutherford made use of zinc sulphide screen. With the help of a chart showing Rutherford *experiment explain scattering of α-particle* to the pupils.

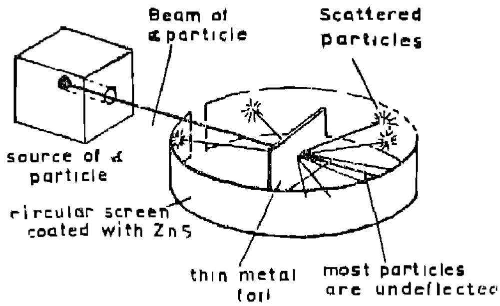
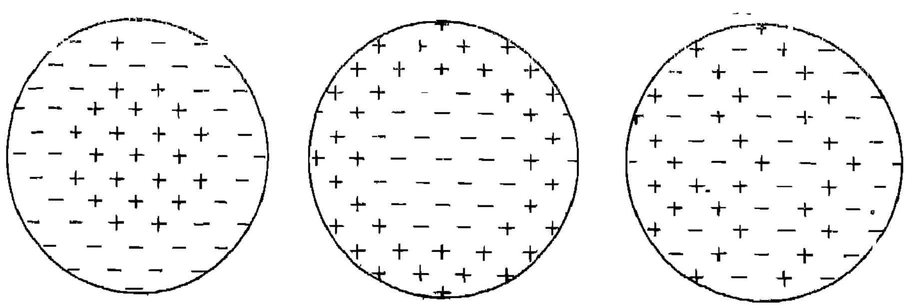


Fig 18.2. Rutherford experiment on α particles scattering



(a)
Model 1 : Positive charge concentrated at the centre

(b)
Model 2 . Negative charge concentrated at the centre

(c)
Model 3 Uniform distribution of positive and negative charge

Fig. 18.1. Various models for the atom

* α particles are helium nuclei i.e 2 positive charges and 4 mass.

Now list out the Rutherford's observations as follows :

(*i*) Most of the alpha particles pass through the thin gold foil undeflected.

(*ii*) Some alpha particles are deflected at fairly large angles.

(*iii*) Very few alpha particles are rebounded back along their path at 180°

In the light of the Rutherford observations you may now discuss that if model 1 which in fact is Thomson model (which may be given the analogy of a 'watermelon' where seeds may be regarded as the negative charge uniformally distributed in the reddish material regarded as positive charge) were true then what do you think should be our observations when α-particles bombard the metal foil ? The answer perhaps may be that most of the α-particles will suffer uniform deflection and this deflection will be very small. Now the question arises Is this model acceptable to us ? Pupils will decline to accept it because it is not in agreement with the experimental observations. Next ask your pupils. Can model 2 answer the observations recorded by Rutherford ? Students might tell that if it were the model of the atom then no α-particles would have been deflected back along their path at 180° and therefore this model also cannot be acceptable On the basis of logical arguments pupils will accept that model 3 only matches the Rutherford observations and so the goldfoil atom-structure used by Rutherford must resemble model 3.

Now with the help of observations recorded by Rutherford and through discussion impress upon the pupils that each observation leads to an independent conclusion, as given below :

1. Since most of the α-particles pass through the foil undeflected, it looks as if the atom were mostly empty space
2. Since only a few α-particles are scattered through very large angles the positive fragment of the atom occupies a very small volume of the entire atom.
3. A deflection of 180° indicates that there is an intense electric field inside the atoms since a positive charge spread over total volume of atom will be incapable of producing such a field.

   Therefore, it is concluded that total positive charge is in the centre of the atom.

This central positively charged massive body of the atom is called nucleus and electrons revolve around the nucleus in the empty space.

Can you draw a picture of the structure of helium atom ?

Concepts 4 to 10 (a general background discussion)

Based on experimental observations, Rutherford postulated that the atom consists of positively charged nucleus, containing practically all the mass surrounded by electrons whose number is equal to positive charge present in nucleus, is revolving around the nucleus. Such a model bears an analogy to our solar system where the earth is revolving around the Sun Can you imagine what would have happened if electrons were stationary ? In comparing the Rutherford model with solar system there is one difficulty. An electron is a

charged particle and any charged particle following circular trajectory must emit radiations. Now if the electron following the circular trajectory continuously emits radiations then it must fall into the nucleus. Such a situation renders an atom as unstable whereas our experience is that atoms are stable. The second important experimental finding was that of 'line spectrum' of the elements which in fact could not be explained by Rutherford model.

To overcome the objections to the Rutherford model and also to explain the *spectrum of atomic hydrogen*, Bohr made a revolutionary suggestion that an electron could revolve around the nucleus only on certain specified circular pattern called 'orbit' without emitting or absorbing any energy. This suggestion alongwith other assumptions is given in the form of following postulates :

1 An atom has a number of stable circular orbits of a definite energy, or "stationery energy states" in which an electron moves about the central nucleus (proton) without the emission of radiant energy.
2. When an electron makes a jump from one of its non-radiating orbits to another of lower energy, radiations are emitted whose energy equals the energy difference between the initial and final states and whose frequency is given by the relation

$$\Delta E = h\nu = E_2 - E_1 \quad \text{or} \quad \nu = \frac{E_2 - E_1}{h}$$

where 'h' is Planck's constant and E_2 and E_1 are the higher and lower non-radiating energy states. This second postulate makes use of the fact that radiant energy is emitted or absorbed in terms of discrete units called quantum (Planck's quantum theory).
3 The angular momentum of an electron following a circular path must be an integral multiple of $h/2\pi$.

(a) Can you explain the presence of so many lines in the hydrogen spectrum, even though hydrogen contains only one electron ?

(b) Are you now in a stage when you can explain the colour imparted to the flame by various elements or their chlorides when they are heated in Bunsen flame ?

Subsequent investigations on the Bohr model led to the following shortcomings :

1. The model does not account for the sharp spectral lines obtained in the case of hydrogen.
2 It is inadequate for multi-electron atoms. (Bohr theory does not take adequate account of the repulsion between electrons).
3. There is no satisfactory solution to the problem as to why only such orbits are permitted as the non-radiating ones for which the angular momentum is an integral multiple of $h/2\pi$.
4 The model fails to answer the question : why do atoms combine to form molecules ?

Wave nature of matter

Bohr's theory was eventually replaced by a new way of viewing the atoms, called quantum mechanics, or wave mechanics. As you still see, the concept of quantized

energy states introduced by Bohr remains, but in addition application of Planck's quantum theory enters the picture.

The central idea in the modern theory of atomic structure is that any moving particle and for that reason electron also is associated with wave properties. The solution to the problem of model for an atom is highly mathematical and therefore you would study some of the qualitative ideas only. de-Broglie suggested that particles which come under microscopic category should behave somewhat similar to photons. Therefore he assumed that electron following a circular trajectory is carried by means of waves that are propagated in space according to the laws similar to those obeyed by light waves. The wavelength associated with the electron of mass m moving with velocity v, following a *circular path is given by the expression*

$$\lambda = \frac{h}{mv} \qquad (1)$$

where λ is the wavelength and h is Planck's constant. Now if the electron is associated with a wave and follows a circular path then the circumference of the circle must be an integral multiple of the wavelength. If r is the radius of the circle, the expression will be

$$n\lambda = 2\pi r \qquad (2)$$

where, $n = 1, 2, 3 \ldots\ldots\ldots$

Expressions (1) and (2) clubbed together lead us to—

$$mvr = n\frac{h}{2\pi}$$

de-Broglie's idea of matter waves has been verified by Davisson and Germer who discovered that a beam of electrons is diffracted from a crystal lattice in the same manner as a beam of X-rays.

What additional evidence therefore we get regarding the nature of electrons from the Davisson and Germer experiment ?

The idea of matter waves put forth by de-Broglie gave birth to another fundamental principle known as Heisenberg's uncertainty principle which is very much evident in the case of microscopic particle. According to this principle, the position as well as momentum of an electron cannot be determined simultaneously. If the probability for the determination of momentum is high then the probability for the determination of position is small Following these two ideas E Schrodinger developed an equation for the propagation of electron waves. The physical significance of this equation is that it counts for electron distribution in space as well as the allowed energy levels for its moving in an atom. In terms of this equation the electron is considered to be disposed around the nucleus in the form of cloud and we only talk of the probability of an electron being found at a particular instant as it moves around the nucleus. Now if we talk of the probability picture then probability at a certain distance from the nucleus may be high and that for others it may be low *The region around the nucleus where the probability of locating an electron is maximum is called orbital.*

A large number of electron orbitals are possible in an atom. Orbitals can be distinguished in a qualitative manner by their size, shape and orientation. An orbital of small size means there is more chance of finding the electrons near the nucleus. Similarly, shape and orientation mean that electron distribution has more probability along certain directions and less along certain others.

Orbitals are precisely distinguished by what are known as *quantum numbers.* It can be shown that each orbital is designated by three quantum numbers. These quantum numbers are labelled as n, l and ml. These three quantum numbers obtained from the mathematical wave equation were found to be related to each other and they correspond directly to the pattern of energy levels. These refer to the size, shape and orientation of the orbital in space. These are known as Principal or size quantum number, Azimuthal or shape quantum number and Magnetic or orientation quantum number. The correlation is given below.

A main energy level is further divided into sub-energy levels indicated by the letters s, p, d and f. Each of these refer to a characteristic value of l. Thus for s, p, d and f, the l values are 0, 1, 2 and 3 respectively.

Apart from the spatial distribution given by the orbital, an electron has an additional characteristic called spin. The spin is also quantized and designated by an additional quantum number, called *spin quantum number*, m_s which can have only two values $+\frac{1}{2}$ and $-\frac{1}{2}$ corresponding to the clockwise and anti-clockwise rotation about an axis. The presence of electron spin turns out to be important in determin-

Principal quantum number (main energy level or shell)	—	n, denotes size of an orbital
Azimuthal quantum number (sub energy level or sub-shell)	—	l, denotes shape of an orbital
Magnetic quantum number	—	ml, denotes orientation of an orbital

Table 18.1

Relationship among values of n, l and m_l through n=4

n	*l*	*orbital designation*	m_l	*number of orbitals*
1	0	1 s	0	1
2	0	2 s	0	1
	1	2 p	1, 0, -1	3
3	0	3 s	0	1
	1	3 p	1, 0, 1	3
	2	3 d	2, 1, 0, -1, -2	5
4	0	4 s	0	1
	1	4 p	1, 0, -1	3
	2	4 d	2, 1, 0, -1, -2	5
	3	4 f	3, 2, 1, 0, -1, -2, -3	7

ing the electronic structures of atoms. It was Wolfgang Pauli who recognised this fact in 1924 and enunciated the principle known as Pauli's "Exclusion Principle". The principle declares that no two electrons in an atom can have the same set of four quantum numbers, n, l, m_l and m_s. The exclusion principle provides the key to one of the great problems of Chemistry—an explanation of the structure of the periodic table of the elements.

From the discussion in the preceding paragraph, what relation do you establish between n and l?

Having known about the fact that each orbital in an atom is associated with different energy, our immediate problem is—how the filling up of electrons in a multi-electron atom takes place? You must have studied the Aufbau principle which gives answer to this problem in the form of a diagram The check to arrive at this diagram is provided by the following rule, known as (n+l) rule. This rule comprises two points :

1. Electrons would occupy that orbital first for which (n+l) value is low. For example, 3d and 4s have 3+2 =5 and 4+0=4 respectively as their (n+l) value ; the (n+l) value for 4s level is low and therefore electrons occupy that orbital first.
2. If the (n+l) value for the two orbitals is same the electrons would occupy that orbital first for which n value is low. For example, 4d

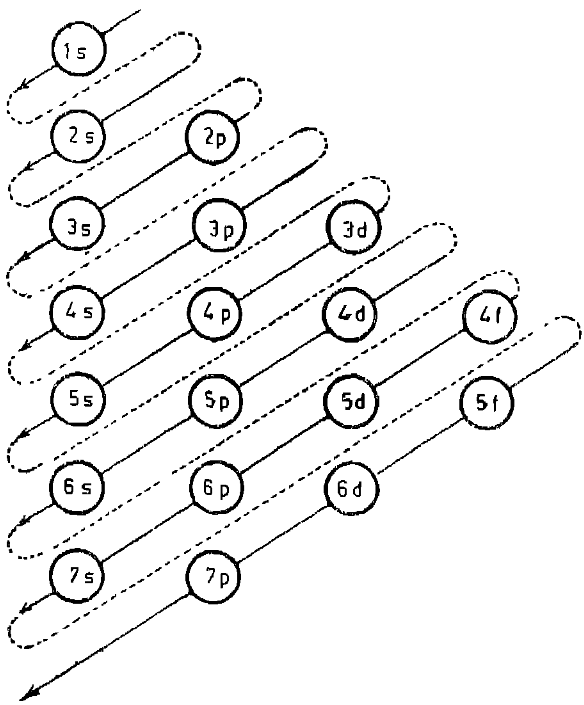


Fig 18.3. Order of filling of orbitals (according to Aufbau Rule)

and 5p orbitals have 4+2=6 and 5+1=6 as their (n+l) value respectively, the (n+l) value is same for both orbitals but n value for 4d level is low, therefore electron will occupy 4d level first and then fill up 5d level.

Out of the following pairs of orbitals, which one will be filled up first
(1) 7s and 4f (2) 6s and 5d

Methodology related to development of concepts

The development of the concept 1 mentioned earlier is taken as an example for you to teach in the class. This can be regarded as the activity that each student can perform in the class You may get the instructions given here cyclostyled and distribute them to each student alongwith the requisite material. Divide the pupils into groups if you feel it necessary The pupils may be asked to record their observations for each part of the activity in their notebook. The following questions based on the student's observation may emerge for discussion :

(i) Why the balloon gets stuck up to the wall when it is rubbed with silken or terylene cloth ?
(ii) When the experimentation is tried with two balloons, why they repel each other ?

Thereafter you should recall the Coulomb's law and induction phenomenon and bring them home through generalization that matter is electrical in nature. Also try to correlate the activity performed with the everyday experiences.

The method suggested here is known as *activity method*. The method used for teaching concept 3 is the *lecture method* While adopting the lecture method you must make use of teaching aids, model, chart etc., at the appropriate places as suggested in the development of this concept. You should follow a suitable sequencing of content which provides an inherent methodology and involve the pupils by frequently asking them questions. All important conclusions should emerge out of discussion only. Although it was not a practical approach yet the sequencing of the content highlights two important steps of scientific method, which are :

1. making hypothesis regarding the models for an atom.
2. testing hypothesis, which of course has been done here on the basis of logical arguments.

Test for Pupils' Achievement

1. The number of positive charges in an atom is equal to :
   (a) the atomic mass of the atom ;
   (b) the valence of the atom ;
   (c) the number of neutrons in the atom ,
   (d) the atomic number of the atom.
2. The atomic mass of an element is 37 and the atomic number is 17, the number of electrons revolving around the nucleus would be :
   (a) 20 (b) 37 (c) 17 (d) 54
3. On directing a stream of energetic α-particle at an extremely thin piece of gold foil, what would you expect to find ?

(a) All α-particles absorbed.
(b) All α-particles transmitted with only small deflection.
(c) Most of the α-particles transmitted with only small deflection, and some of them scattered through large angles
(d) Some α-particles transmitted with only small deflection and most α-particles scattered through large angles

4. For the four radiations i.e. violet, red, blue and orange, the order of increasing energy of a quanta for each of these radiation will be
   (a) Violet > Red > Blue > Orange
   (b) Red < Orange < Blue < Violet
   (c) Violet > Blue > Orange > Red
   (d) Violet < Red < Blue < Orange
5. Which of the following is the description of the orbital ?
   (a) A region inside the nucleus where the probability of finding the electron is maximum.
   (b) A region of space around the nucleus where the probability of finding the electron is maximum
   (c) A region outside the nucleus where electron revolves in definite energy shells.
   (d) It is the innermost energy shell around the nucleus.
6. For the orbitals 4s, 3d, 4p and 5s the order of increasing energy for the filling up of electrons is
   (a) 4s < 3d < 4p < 5s
   (b) 3d > 4s > 4p > 5s
   (c) 4s < 3d > 4p < 5s
   (d) 3d > 4s > 4p > 5s

Method Used

This chapter is the most *abstract unit*, since most of the experiments/demonstrations are not feasible in the school situation. Except one or two experiments like *electrical nature of matter*, most of the concepts are to be developed by lecture-cum-demonstration method If we consider scientific method, we come across demonstration of experiments, observation, collection of data/ideas, interpretation of data/hypothesizing, verification of hypothesis and, finally, generalisation. Here generalisation part is very important and leads to principles/laws. Most of the scientific discoveries are based on generalisations. Do you consider it possible to generalise all the basic ideas on the basis of demonstration/experimentation in the classroom ? Will time budget permit you to do so ? What other effective methods do you consider are feasible in your school situation which normally take less time ?

As you have seen in the present chapter, there is not much scope for demonstration for the development of concept. In such a situation teaching aids like models, charts, etc become very vital. For such topics, information/data, which students are supposed to collect from the experiments, you provide them through charts and tables, and based on such information, have discussion to hypothesize and finally, to generalise. For example, scattering of α-rays through thin gold foil is not possible to show in the classroom but it is possible to show a chart showing the experimental set-up, in which deflection of α-rays is properly depicted. Let the student generalise on logical arguments.

This chapter is intended to provide a *model for an atom*. For this, it is necessary

to collect various concepts which are based on various generalisations. In the light of those concepts, one can think of a model. Now, testing of a model is again not possible in the school situation, but definitely that can be done on the basis of logical argument. Similar to the model of an atom you will come across model for a gas. But the beauty lies in the fact that the validity of the 'model' for a gas can be tested by designing suitable experiments in the classroom.

A sequential development of the concept provides an inherent methodology of a particular discipline which you should follow strictly while teaching. This will help you in applying known laws and principles to understand new ideas/concepts.

Assignments for the Pupil-teacher

1. Perform the activity given in the development of Concept 1 with the help of plastic rod-fur and glass rod-silken cloth combinations using pith balls. Further, extend it by using rubber rod-fur and wood rod-silken cloth combinations.
2. Perform the electrolysis of acidulated water with platinum electrodes and aqueous solution of copper sulphate using copper electrodes and correlate the changes with the nature of matter.
3. Improvise a photo-electric cell in the laboratory.
4. Prepare a lesson plan to communicate the idea that atoms consist of electrons, protons and neutrons. What methodology will you use here ?
5. Prepare models for different atoms using beads of different colours mounted on chart paper or on cloth background. What ideas can you communicate to the pupils regarding the structure of an atom through these models ?
6. Supposing you have to teach Concept 3 given in the unit through discussion method, what sub-topics to the groups will you assign ?
7. Making use of beads, can you communicate the idea of Thomson and Rutherford model ?
8. Prepare a chart showing different ways in which an atom may be excited.
9. A ball is rolling down the staircase step by step. Where do you think this situation will help you to convey some idea, if at all, about the structure of atom ?
10. In how many ways you can show the filling up of electrons in orbitals according to their increasing energy?

    Attempt through chart.

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3. *Textbook of Physical Chemistry*, A. J. Mee
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CHAPTER 19

Periodic Properties of Elements

Introduction

To acquire systematic and informative knowledge classification of the things in hand is the inherent desire of a man. With the introduction of a large number of elements and as the quantity of chemical information grew, chemists felt the need of classifying elements. From our daily life experiences, we know that every classification needs a definite set of criteria. The earlier attempts to classify the elements were based upon the physical and chemical properties of the elements known by that time. Recent work of chemists has established that the physical and the chemical properties of elements are dependent on the number of electrons and their arrangement around the nucleus. Therefore the latest work to classify the elements is based on the electronic configuration (modern periodic table or long form). In the present Unit you will see how properties of the elements are related to electronic configuration or atomic structure. You will realize that teaching of periodicity of properties of the elements is one of the fundamentals to be provided at the initial stages of teaching chemistry.

Major Objectives

1. To develop the understanding that classification needs a criteria.
2. To explain the basis on which the modern periodic table is constructed.
3. To develop the concept of periodicity and gradation in the properties of elements
4. To describe the various blocks of elements in the periodic table in terms of the type of orbital occupied by electrons

Major Concepts

1. Elements when arranged in order of increasing atomic number, exhibit periodicity in properties
2. Periodicity in properties of elements

is explained on the basis of electronic configuration.

3. On the basis of electronic configuration, elements are classified into s, p, d and f blocks.
4. Elements in groups and periods exhibit gradation in properties

Silks

1. Predicting behaviour of the unknown element on the basis of their atomic structure.
2. Writing electronic configuration of the elements

A General Discussion of Concepts

When the elements are arranged in order of increasing atomic number as shown by the chart 19.1, it is found to consist of seven horizontal rows which are called periods. Each period starts with a new principal quantum number (n) and filling up of electrons in orbitals takes place according to the Aufbau principle (discussed in previous Chapter). Filling up of the elections in orbitals is known as electronic configuration Let us start with the first period which has two elements, hydrogen ($1s^1$) and helium ($1s^2$). With these two elements placed in the first period, the first shell (k) is completed The second period starts with (n=2) the first member of which is lithium ($1s^2 2s^1$) and this shell is completed at neon ($1s^2 2s^2 2p^6$). By taking examples of other periods also, it can be shown that each period follows suit.

Let us now define 'blocks' of elements in the periodic chart, on the basis of electronic configuration

Elements of s-block : These are the group IA (alkali metals like Li, Na and K) and group II A (alkaline earth metals like Be, Mg, Ca and Si) elements with the general outermost electronic configurations ns^1 and ns^2 respectively.

Elements of p-block : This block of elements covers from group III A to VII A with the outermost electronic configuration varying between $ns^2 np^1$ to $ns^2 np^5$ and zero group with $ns^2 np^6$ configuration. A typical series of these elements is B, C, N, O and F which starts with $2s^2 2p^1$ configuration and ends at $2s^2 2p^5$ configuration Elements in the zero group (noble gases) with $ns^2 np^6$ come at the end of this block.

Elements of the s and p-blocks are often called representative elements. These elements attain noble gas configuration by entering into chemical combination through losing, gaining or sharing electrons.

Elements of d-block · These are the transition elements (III B to II B in the centre of the periodic table) with common electronic configuration $(n-1)\,d^{1-10}\,ns^{0-2}$. In these elements n is 4, 5 or 6 and 3d, 4d or 5d orbitals are being filled The 3d series of transition elements starts with scandium ($3d^1 4s^2$) and ends at zinc ($3d^{10} 4s^2$) with copper falling before zinc with electronic configuration ($3d^{10} 4s^1$) All these elements usually exhibit variable valency and form complex compounds (why) ?

Elements of f-block · These are the elements arranged in two rows at the bottom of the periodic table. The first row is known as Lanthanide series with elements bearing atomic number from 58 to 71 and the second row is actinide series with elements bearing atomic numbers from 90 to 103. Elements of lanthanide and actinide series have incomplete 4f and 5f orbitals respectively. In addition, these elements also have incomplete $(n-1)$ d orbitals. Here the filling up of the electrons takes place in f-orbitals.

LONG FORM PERIODIC TABLE

Representative Elements — Representative Elements — TRANSITION ELEMENTS — PERIODS

Groups / Periods	IA	IIA	III B	IVB	VB	VI B	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
1	H 1																	He 2
2	Li 3	Be 4											B 5	C 6	N 7	O 8	F 9	Ne 10
3	Na 11	Mg 12											Al 13	Si 14	P 15	S 16	Cl 17	Ar 18
4	K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36
5	Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54
6	Cs 55	Ba 56	La 57	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
7	Fr 87	Ra 88	Ac 89	Ku 104	Ha 105													
6	Lanthanide Series			Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71	
7	Actinide Series			Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103	

19 1—Long form of Periodic Table

The long form of the periodic table as you have observed is based on the relative filling up of orbitals. This form of the periodic table is in excellent agreement with quantum mechanical model of the atom because here the number of elements in a period resembles well with relative filling of the orbitals as shown in the table given below.

Table 19.1

Number of elements in a period as related to filling up of orbitals involved

Period	*Filling of the orbitals of the elements present in the period* s	f	d	p	*Number of elements in the period*
1	1s				2
2	2s			2p	8
3	3s			3p	8
4	4s		3d	4p	18
5	5s		4d	5p	18
6	6s	4f	5d	6p	32
7	7s	5f	6d	7p	32

You must have noticed that the number of groups in the modified* Mendeleev's periodic table and long form is the same. However, long form periodic table is based on electronic configuration of the elements. What conclusion can you draw from this information? The obvious answer seems to be that *when elements are arranged according to their electronic configuration, elements of similar properties get repeated after certain interval.* This is known as *periodicity*. Let us now examine some properties like atomic size, ionization energy, electron affinity and electron negativity These are the properties which play an important role in determining the chemical behaviour.

Atomic size It is very difficult to measure the size of an isolated atom. However, scientists have measured the radii of atoms by several methods. The radius of an atom is regarded as a measure of its size. The radii of the atoms are different under different environments (Discuss, covalent radii, ionic radii, metallic radii and van der walls radii).

The size of an atom in a period decreases regularly with an increase in the atomic number of elements. The atomic radii of the elements of 3d period are shown in Table 19.2.

* Mendeleev's periodic table which was based on chemical properties was initially arranged in increasing order of atomic weights but after Mosley work related to X-rays, periodic table was arranged as per atomic number of the elements

Table 19.2

Atomic radii of the elements

Na	*Mg*	*Al*	*Si*	*P*	*S*	*Cl*	*Elements*
1.57	1.36	1.25	1.17	1.10	1.04	0.99	Atomic radius (Å)

This behaviour can be easily explained Along a period electrons are added to the same shell or sub-shell while the charge on the nucleus increases. This should result in a greater degree of attraction between the nucleus and the electron and hence the size decreases.

The size of atoms in a group increases with increase in atomic number. This is illustrated in Table 19.3 where alkali metals have been taken for simplicity

Table 19.3

Elements	*Atomic radius (Å)*
Li	1.23
Na	1.57
K	2.03
Rb	2.16
Cs	2.35

This is because electrons are added to new shells as we go down in any group

Ionization Energy

It is possible to remove an electron from neutral atoms by supplying energy The energy required to remove the most loosely bound electron is lower than that for the others This energy would be a measure of the strength with which the electron is bound to the nucleus of the atom. In order to have comparative values of this energy for various atoms we define *the first ionization energy as the minimum energy required to remove the most loosely bound electron of a free gaseous atom* When an electron is removed from a neutral atom, a positively charged ion results

$$M(g) + \text{energy} \longrightarrow M^+(g) + e^-$$

We expect the ionization energy to increase as the nuclear charge increases (why ?). Let us examine the first ionization of the elements of the second period (Table 19.4)

Table 19.4

Atomic No.	3	4	5	6	7	8	9	10
Element	Li	Be	B	C	N	O	F	Ne
Ionization energy (kJ/mol)	520	900	800	1086	1403	1314	1681	2081

The data to a large extent supports our expectations. Let us examine the first ionization energies of the elements down a group (Table 19.5).

Table 19.5

Atomic number	*Element*	*Ionization Energy (kJ/Mol)*
3	Li	520
11	Na	495
19	K	418
47	Rb	403
55	Cs	374

This is easily explained because as we move down the group, the size of the atom increases and the hold of the nucleus over the electron decreases.

An interesting thing that needs to be emphasised here is that s-block elements have low ionization energies, p-block elements have high ionization energies whereas the values for d and f-block elements fall intermediate between s and p-block elements. The d and f-block elements also show almost constancy towards variation in ionization energies with the atomic number (why ?) This justifies the division of elements into s, p, d and f blocks.

Electro-negativity · The ionization energy measures the strength with which electrons are held by individual atoms In a bonded situation, ionization energy may determine which of the two unlike atoms have a greater attraction for the electrons. The property of an atom in such a bonded situation is defined as its electronegativity.* *Electronegativity, therefore, is a measure of attraction that an atom in a molecule has for shared electron pair.* The following data will give an indication of the trends in electronegativities. Electronegativities of the elements are given below against the symbol of each element ·

Table 19 6
Electronegativity of some elements

Li	Be	B	C	N	O	F
1 0	1 5	2 0	2 5	3 0	3.5	4.0
Na	Mg	Al	Si	P	S	Cl
0.9	1 2	1 5	1 8	2 1	2.5	3.0
K	Ca					
0 8	1 0					

1. **What trend do you observe along a group and a period ?**
2. **What correlation do you establish between ionization energy and electronegativity of the element ?**
3. **Electronegativity is also a periodic property. Justify this in the light of the above data.**

The difference in the electronegativities of the two elements helps us to keep an account of the partial ionic character of a bond. For example, say in a covalent bond, A—B, established between two elements A and B, E_A and E_B are the electronegativities of the elements A and B respectively and $\triangle E$ denotes the difference in their electronegativities. Then mathematically, $\triangle E \propto$ partial ionic character of the bond. This partial ionic character of the covalent bond throws light on the dipole moment of the bond.

Development of Concepts 1 and 2 Through Activities

First of all give a brief account for the need of periodic table to the students. Ask the pupils to perform the following activity.

Commonly available elements such as sodium, potassium, aluminium, silicon, carbon (graphite), calcium, phosphorus, magnesium, sulphur and chlorine (prepared in the laboratory) be shown to the pupils. Note their state, appearance, hardness/softness, action with cold and hot water and with acids. Ignite the elements to form their oxides Dissolve the oxides obtained in water and test the resulting solution with blue and red litmus papers Thereafter tabulate your results as in Table 19.7.

Make groups of the elements which show resemblance in their properties. You know their atomic number. Arrange the elements in such a way that elements with the same number of electrons in their outermost orbit fall below each other What relation do you observe between the properties and their arrangement according to increasing atomic number ? You notice that when elements are arranged according to increasing atomic number, elements of similar

* Normally we discuss electronegativity in the Chapter 'Chemical bonding' where it describes the tendency of an atom to become negatively charged in its covalent compounds Whether a covalent compound will be polar or non-polar can be easily decided on the basis of electronegativity of the elements involved.

Table 19.7

Name of the Element	*State*	*Apppearance*	*Hardness/ Softness*	*Action with Water*	*Action with Acids*	*Behaviour of Oxide*
Sodium						
Potassium						
Magnesium						
Aluminium						
Silicon						
Carbon						
Calcium						
Phosphorus						
Sulphur						
Chlorine						

properties come after a definite interval. This is known as periodicity. Now ask your pupils to write the electronic configuration of elements with atomic number 1 to 20 on separate cards (5 cm × 10 cm) and arrange these cards as done earlier according to increasing atomic number. Now ask your pupils what relationship do they observe between the properties of elements and their electronic configuration ? Pupils will perhaps be able to answer that periodicity can be explained on the basis of electronic configuration of the elements Then discuss the properties and electronic configuration of the elements with atomic number more than 20 and help the pupils in generalising that other elements also follow suit.

Predict properties of the elements which are not included in your table which you have prepared in this activity.

Development of Concept 3

Take in two test tubes containing aqueous solutions of sodium bromide and sodium iodide respectively. And chlorine water to both. Add a little of carbon tetrachloride to each of the test tubes and shake the solution. What do you observe ? Now in another test tube take aqueous solution of sodium iodide add bromine water along with carbon tetrachloride. Now repeat this experiment separately in a test tube by taking aqueous solution of sodium chloride and adding bromine and iodine

alongwith carbon tetrachloride in each case Record your observations and draw inference in each case and match them with the following table .

Table 19 8

	System	Observation	Inference
1.	Aqueous solution of bromide salt + chlorine water + Carbon tetrachloride	Formation of brown ring	Chlorine liberates bromine from bromide
2.	Aqueous solution of iodide salt + carbon tetrachloride + chlorine water	Formation of violet ring	Chlorine liberates iodine from iodide
3.	Aqueous solution of iodide salt + bromine water + Carbon tetrachloride	Formation of violet ring	Bromine liberates iodine from iodide
4	Aqueous solution of chloride salt + bromine water + Carbon tetrachloride	No change (neither appearance of a new colour nor disappearance of bromine colour)	Bromine cannot liberate chlorine from chloride
5	Aqueous solution of chloride salt + iodine water + carbon tetrachloride	No change	Iodine cannot liberate chlorine

In the above cases, after performing the experiment, let pupils draw conclusions based on their observations

Perhaps the pupils' conclusion will be that chlorine is more reactive than bromine which in turn is more reactive than iodine. At this stage you discuss the changes that follow in the above systems

$2Br^- + Cl_2 \rightarrow 2Cl^- + Br_2$ (1)

$2I^- + Cl_2 \rightarrow 2Cl^- + I_2$ (2)

$2I^- + Br_2 \rightarrow 2Br^- + I_2$ (3)

where $\rightarrow$ shows electron transfer from one species to the other Now inform your pupils that the reactions indicated above depend upon electron attracting power of the halogens from halides and ask the following questions.

(i) What relationship do you observe between the reactivity of halogens and their electron attracting power ?

(ii) What do you think should be the order of electron attracting power in the case of halogens ? Pupils will conclude that electron attracting power (electron affinity) in the case of halogens should be : chlorine > bromine > iodine. Now you may give them the following data regarding electron affinity for halogens and discuss in detail about electron affinity.

Species	*Electron affinity in kJ/mol*
F	333
Cl	348
Br	340
I	297

Students have now learnt that in the case of halogens the reactivity decreases gradually down the group and so does electron affinity,

This is gradation in properties exhibited by halogens in group *The method adopted above is known as Inductive method* Here, pupils have discovered everything themselves and the teacher has only helped them in arriving at the right conclusion.

Gradation in properties along a period

You may take the case of oxides of the elements of the third row of the periodic table and discuss gradation in their acidic character and then interpret it in terms of electron affinities of the atoms of the element belonging to this row. Your method and approach will be the same as discussed above for gradation in properties in the case of halogens.

Test For Pupils' Achievement

1. Match the following :

(*i*)	$ns^2\ np^5$	(a)	Alkali metals
(*ii*)	ns^1	(b)	Actinide element
(*iii*)	$ns^2\ np^6$	(c)	Lanthanide element
(*iv*)	$4f^1\ 5d^1\ 6s^2$	(d)	Noble gases
(*v*)	$5f^3\ 6d^1\ 7s^2$	(e)	Halogens.

2. In the periodic table, the size of the atoms in a period from left to right—
   A. Increases regularly
   B. Decreases regularly
   C. First increases and then decreases.
   D. First decreases and then increases.

3. Which of the following characteristics is responsible for the common chemical behaviour of elements in any group of the periodic table ?
   A Atomic size of the element
   B. Atomic mass of the element
   C. Electronic configuration of the atoms of the elements.
   D Number of protons and neutrons in the atoms of the elements

4. Which amongst the following would react most vigorously with water ?
   (*i*) Li
   (*ii*) Na
   (*iii*) K
   (*iv*) Rb

5. Which of the following configurations corresponds to element having the lowest first ionization energy ?

(*i*)	$1s^2$	$2s^2$	$2p^6$	$3s^1$	
(*ii*)	$1s^2$	$2s^2$	$2p^6$	$3s^2$	
(*iii*)	$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^1$
(*iv*)	$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^2$

Method Used

What method will you follow in teaching this chapter ? This unit is based on the basic ideas of scientific process classification. Classification of elements is based on their properties. As you know, if students start classifying elements based on the properties which they study themselves (as a pupil activity), it may not be possible to cover all the properties. Therefore, only a few properties of common metals can be indicated The best way of doing this is to write all the properties of a few elements on a card and arrange those cards in an increasing order of atomic number. Repetition of properties will give an *idea of periodicity. In most cases, you may not be in a position to provide individual pupil activities, therefore, in such cases demonstrate yourself* Before the students reach a conclusion, there should be a discussion.

The *process of classification* may be equally useful in the study of metals, non-metals, and organic compounds belonging to a particular functional group

Inductive and *deductive* approaches are quite common. In case of the inductive method of study, we normally start from experiments/measurements and arrive at a particular generalisation. However, in the case of deductive method, we are familiar with the final conclusion and try to prove with known evidences using suitable devices. Inductive and deductive approaches can be applied in any of the units. However, inductive approach is preferred as it encourages inquiry and search for new ideas in students. As mentioned earlier, in many cases, students generalise on the basis of their activities Provide data to your students and help them in generalisation after discussing the data

Assignments

1. Prepare a chart of the long form of periodic table.
2. If you have to teach the long form of the periodic table through lecture method, apart from making of the periodic table, how do you make your lesson interesting ?
3. Prepare a lesson plan to teach the concept of ionization energy What special skill do you want to inculcate in your pupils through the teaching of the concept ?
4. "Prediction about the behaviour of an unknown element is the special skill in the periodic table".— Comment upon this
5. Prepare a periodic table showing (separately) the atomic and ionic sizes of the 'element. (Use two colour schemes for atomic and ionic sizes using coloured circles)
6. From the relative position of barium in the periodic table predict the solubilities of its hydroxide and sulphate and test it by conductance measurements.
7. In what region of the periodic table are located those elements which have the tendency to form strong oxy-acids ?
8. Prepare a long form of periodic table and show the boiling point, the melting point, and density against each element and find out periodicity, if any, in property.

REFRENCES

In addition to the books mentioned in the chapter on Structure of Atom, the following reading material is also recommended -

1. *Chemistry, A textbook for Secondary Schools*, NCERT, 1975.
2. *Chemistry, A Textbook for Higher Secondary Schools*, NCERT, Parts I & II (1977-78 publication)
3. *Electronic configuration of atoms, atomic properties and periodicity* (Content Enrichment Material for Secondary School Teachers, NCERT, 1977).

CHAPTER 20

Chemical Bonding

Introduction

The atomic theory has convincingly explained how all matter can be regarded as being composed of atoms. But atoms rarely exist free in nature. They are almost always in combination leading to the naturally occuring elements and compounds. The synthetic chemists have also produced a variety of compounds.

The next logical step to the atomic theory would obviously be to try to use it to explain why and how atoms combine with one another. The nineteenth century view of 'valency' (combining capacity of atoms) was based on Dalton's atomic theory. But it had many serious inadequacies; for instance to say that the valency of oxygen is *two* and of hydrogen is *one* does not really mean much as it does not assign any reason for the same. It is only a different way of saying that the molecular formula of water is H_2O. Why does water have this formula and not some other formula ? Why does water have its characteristic properties ? Obviously the original atomic theory was not developed enough to explain these.

The picture became clear only with the emergence of the electronic structure of the atom. With a knowledge of the electronic arrangements, we are now in a position to explain the NATURE OF THE CHEMICAL BOND between atoms.

In the present Chapter you will come across various concepts in the area of chemical bonding and will learn how to develop them logically.

Concepts

1. The octet rule tries to correlate electronic configurations of atoms with their tendencies to form chemical bonds.
2. Bonding occurs if it can lead to lowering in energy of the atoms concerned.

3. Lowering of energy during bonding results due to simultaneous attraction of the electrons by the nuclei of the combining atoms.
4. The equilibrium bond length is the inter-nuclear distance between the approaching atoms at which the forces of attraction and repulsion are balanced.
5. When the difference in electronegativities of the combining atoms is very large, there would be a transfer of electron(s) from one atom to another atom and the resulting ions are held in combination by electrostatic forces.
6. Covalent and electrovalent bonds give different properties to the compounds which contain them

Objectives

1. To explain the formation of a chemical bond using the octet theory.
2. To differentiate between the mode of formation of covalent and electrovalent bonds
3. To explain how energy is lowered when a bond is formed between two atoms.
4. To define 'bond length', 'bond energy', 'bonding capacity' and 'valence electrons'.
5. To predict the bonding capacity of atoms from their electronic configurations.
6. To predict the type of bonds between various combining elements based on their electro-negativities.

Development of Concepts Through Activities

The octet theory tries to correlate electronic configurations of atoms with their tendencies to form chemical bonds. You may present a chart containing the electron configurations of atoms of some alkali metals, halogens, a few more common elements from the middle of the periodic table and noble gases. You ask the students to recall that all elements other than noble gases are reactive. A comparison of electronic configurations reveals that the noble gases have a special configuration. Possibly this speciality of configuration provides them stability and does not allow for undergoing any chemical combination.

If so, the other elements which do not possess this stable configuration must be ready to combine (exhibit reactivity) and the combination must result in a stable configuration, i.e. noble gas electron configuration for each atom in the combination Here you use examples of several pairs of elements from the chart to explain how this occurs in each case.

The development adopts the discussion method moving from the known properties of some elements and their electronic configurations to the Octet theory. The students are encouraged to relate electronic configurations to reactivities of elements and hence to arrive at the octet theory as a generalisation.

Concept No. 3 Lowering of energy during bonding results due to simultaneous attraction of the electrons by the nuclei of the combining atoms.

You initiate the discussion with a brief

review of structure of the atom with special emphasis on the arrangement of the electrons in various orbits. *Hydrogen atom being the* simplest atom is taken up for further discussion. Now if you bring two isolated atoms of hydrogen gradually close and close, what would happen ? To answer this, many queries automatically come to our mind.

(*i*) What holds the electron of each hydrogen atom in a particular orbit ?

So, each hydrogen atom can be regarded as a positively charged nucleus holding an electron at a certain distance from it. This can be represented as follows :

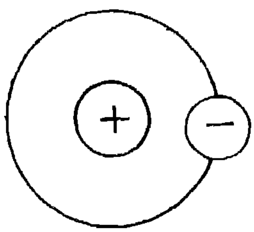

Fig. 20.1. A diagrammatic representation of hydrogen atom

Let us designate the two hydrogen atoms as A and B.

(*ii*) If B is brought close to A, what influence will the particles contained in B (nucleus and electron) have on the electron in A ? Let us represent the influence, diagrammatically as follows :

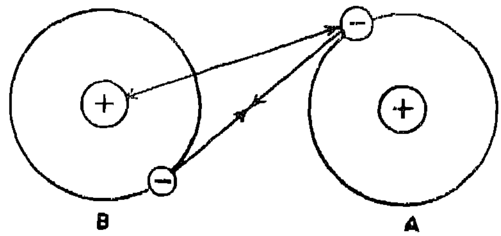

Fig. 20.2. Influence of particles in hydrogen atom B over the electron in hydrogen atom A.

(*iii*) Similarly what influence will the electron and nucleus of atom A have on the electron in B ? Complete the diagram.

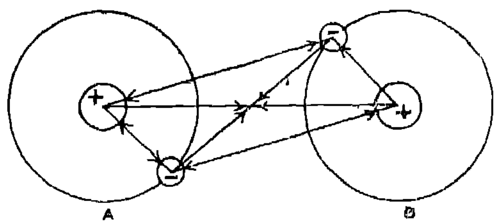

Fig. 20.3. Interaction between particles contained in atoms A and B

(*iv*) When the two atoms are close to each other what influence do the two nuclei have on each other ?

List, in a table, the forces of attraction and repulsion existing when the atoms A and B are very close to each other.

Forces of attraction	*Forces of repulsion*

Given below are the data about the energy effects due to interactions between the various particles in H_2

Table 20.1

Energy effects due to particle interactions in H_2

	Separated atoms (*kJ*)	*Mole-cules* (*kJ*)	*Net effect* (*kJ*)
Average potential energy, P.E. Electron-electron repulsions	0	+2846 58	+2846 58
Nucleus-nucleus repulsion	0	+1876 82	+1876 82
Electron-nucleus attractions	—5241 72	—10878 18	—5630 46
P.E.	—5241 72	—6148.78	— 907.06
Average kinetic energy K E.	+2620 86	+3074.39	+ 453.53
Total Energy, E	—2620.86	—3070.39	— 453.53
Inter-nuclear distance		0.74A°	

What conclusion can you draw from this data about the effects on the total energy, due to (i) forces of attraction and (ii) forces of repulsion ?

A natural tendency of all systems is to reach a state of as low an energy as possible. Therefore, you know now why two hydrogen atoms combine with each other

You have observed that when the atoms are brought near each other there will be introduced both forces of attraction and repulsion. If the energy has to be minimised what should happen to the forces of attraction and repulsion ? How can the forces of repulsion be reduced and how the forces of attraction be increased to have a unity of two atoms ? There must, therefore, be a particular distance between the two nuclei at which these opposing forces are balanced. This distance is called the bond length.

The discussion above explains how as the result of bringing two atoms of hydrogen close to each other the electron of each hydrogen atom is subject to an attraction by two nuclei. It is this simultaneous attraction of an electron by the nuclei of the combining atoms which must be responsible for lowering the energy and binding the atoms to each other.

While developing Concept No. 1, we were brief in presenting the logical sequence. The kind of questions to be raised, problems to be posed, etc. were taken to be implicit. This was because the octet theory is a very common approach at the secondary school level to the explanation of formation of the chemical bond ; but this cannot be said about the concept of energy lowering that occurs when bonds are formed. Therefore, in the above discussion, we have been a little more explicit in detailing the steps.

Method Used

What method will you adopt in teaching this chapter ?

In this chapter, demonstrations are not *easily* possible and development of concepts is based only on logical discussion, taking suitable examples of known elements and compounds. For example, the idea of generalising octet theory comes from the study of known noble gas elements which

have got eight electrons in their valence shell, and study of many compounds which attain eight electron configuration during combination and are as stable as noble gases Here, by taking electronic configuration of a few known elements and compounds it could be possible to generalise the 'octet rule'

Similar to other Chapters, you can prepare a chart showing electronic configuration of various elements and compounds where they have formed octet. For showing chemical bonding between two elements, make use of coloured chalk Electron of one element can be shown in one colour and electron of the other elements can be shown in another colour.

Assignments

1. A plot of E vs r is given below for H_2 molecule. Interpret the plot (E=energy, r=internuclear distance)

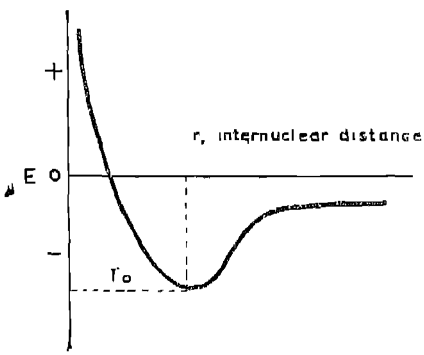

Fig. 20.4 Potential energy diagram

2. In terms of the electronic interactions, explain why He_2 molecule cannot be formed ? How would you discuss this in the class ?
3. One important test for electrovalent compounds is that they conduct electricity. An aqueous solution of hydrochloric acid conducts electricity, but HCl gas does not. Select and discuss a suitable strategy to provide an explanation for this fact.
4. Make an improvised apparatus to identify electrovalent and covalent compounds using conductivity as a criterion.
5. When a charged glass rod (charged by rubbing glass against silk) is held near a stream of water flowing from the tip of a burette, the stream is bent. Allow your students to repeat this experiment with other liquids (alcohol, chloroform, acetone, carbon tetrachloride). Ask them to classify the liquids on the basis of their observations and suggest models to explain why bending occurs in some cases. Invite suggestions for further investigations to support their hypotheses.
6. Supply the following information to the students :
   (1) Names of some electrovalent and covalent compounds (six each)
   (2) A chart of electronegativities of elements. Seek answers, based on this information, from your students for the following questions :
      (a) Why are some combinations electrovalent ?
      (b) Why are some combinations covalent ?
      (c) Why are some covalent compounds polar ?
7. If you involve your students in the development of models for the

chemical bond, you will hopefully be facing a number of ticklish problems posed by them. Some examples are:

(a) Why is CCl_4 a low melting solid whereas NaCl has very high melting point?

(b) Why is CCl_4 non-polar though each C-Cl bond is polar?

(c) Why are some covalent compounds liquids and some gases at room temperature?

(d) Why is NaCl a hard crystalline substance although its constituent sodium is a very soft solid and chlorine a greenish yellow gas?

Think how you will attempt to answer these questions in keeping with the level of your class

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CHAPTER 21

Model for Gases—Kinetic Theory

Introduction

The particles constituting substances are normally atoms or molecules. So far you have studied the structure and properties of isolated atoms and molecules in the previous Chapters. In normal practice, most of the observable characteristics of chemical systems represent bulk properties of matter, i.e. properties associated with collection of atoms, ions or molecules. The property of a substance depends upon the ways atoms, ions or molecules are arranged in bulk. For example, when we consider two forms of carbon, diamond and graphite, we find the difference in properties. The former is hard and transparent whereas the latter is soft and black Here difference in properties is not characteristic of individual carbon atom but the way the atoms are arranged in bulk. Similarly we can cite the example of the most commonly available substance, water, which is chemically represented as H_2O and shows entirely different properties in its three states—gaseous (steam), liquid (water) and solid (ice).

In the gaseous state forces are much weaker as compared to liquid and solid-states Because of strong forces, a solid retains a definite shape. Conversion of one state into another is due to the factors affecting these forces. The gases can be converted into liquids and solids; and the latter two back into gaseous state without altering the chemical composition by suitably adjusting the temperature and pressure. We can expect *that a theory about the nature and properties of gases should provide an insight into the nature of liquids and solids*. Therefore, in the present Chapter, we shall deal with the properties of gases and consider a theoretical model which can explain the properties observed.

Major Objectives

(*i*) To acquaint the pupils that volume

of a definite mass of a gas changes with change in pressure (at constant temperature).

(ii) To acquaint the pupils that volume of a definite mass of a gas changes with change in temperature (at constant pressure).

(iii) To acquaint the students with the effect of temperature on pressure at constant volume.

(iv) To enable the pupils to know that volume of one mole of a gas at STP is 22.4 litres

(v) To relate the rate of diffusion of a gas with its density and molecular mass.

(vi) To enable the pupils to relate the physical quantities (such as mass, volume, temperature and pressure) with each other and express the same in the form of an equation for a gas.

(vii) To enable the pupils to explain the microscopic properties of gases (such as diffusion, pressure, temperature, high compressibility, etc.) at microscopic level with the help of a model and also to think of similar models for liquids and solids.

(viii) To enable the pupils to realize that relationship between pressure, temperature and volume (PV=nRT) is not valid under all conditions (deviation from ideal behaviour).

Major Concepts

(i) At constant temperature, volume of a given mass of a gas varies inversely proportional to its pressure.

(ii) At constant pressure, volume of a given mass of gas is directly proportional to its kelvin temperature.

(iii) At constant volume, the pressure of a given mass of a gas is directly proportional to its kelvin temperature.

(iv) Rates of diffusion of gases are inversely proportional to square root of their densities under similar conditions of temperature and pressure.

(v) (a) Equal volume of two gases at the same temperature and pressure contain equal number of molecules.

(b) At STP, volume of a mole of a gas is 22.4 litres.

(vi) Behaviour of an ideal gas is explained by PV=nRT relationship.

(vii) Behaviour of a gas can be explained by a kinetic molecular model

(viii) Gases deviate from ideal behaviour because of certain factors.

(ix) Behaviour of solids and liquids can be explained with the help of a kinetic model similar to gases

Skills

(i) Manipulation of data,

(ii) Improvising and setting up of apparatus,

(iii) Plotting a graph for a given data (extrapolation and interpolation),

(iv) Suggesting models (theoretical) based on experimental data,

(v) Modifying models,

(vi) Extending models for new situations,

(vii) Drawing generalization about qualitative relationship between variables.

Concept Development Through Activities

Concept : *At constant temperature, volume of a given mass of gas varies in-*

versely proportional to its pressure

The concept can also be stated as "the product of pressure and volume of a given mass of gas is constant at a constant temperature" Develop this concept by *demonstration-cum-discussion method* as detailed below.

Demonstration-1

Materials and Apparatus

50 cm^3 glass syringe, ebonite disc (for raising a circular platform over piston), weight box, rubber cork.

Procedure

Remove the piston from the syringe and raise a circular ebonite platform over it (using quickfix). Now place the piston back into the syringe. Close the nozzle of the syringe by wrapping adhesive-tape over it. To achieve airtightness, insert the wrapped nozzle into a rubber cork as shown in Figure 21.1. Now the apparatus is ready for experiment. Raise the piston upto mark of 45 cm^3 in the syringe (mass of the piston should be determined beforehand). For taking observations, go on putting weights over the platform and recording the change in volume of the syringe.

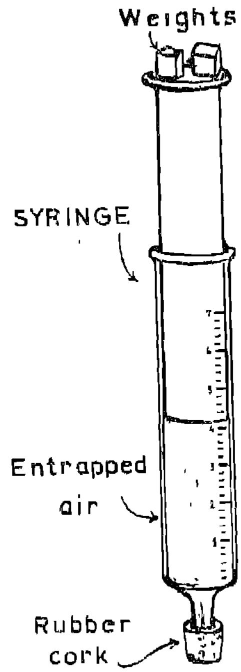


Fig. 21.1. Verification of Boyle's Law

Observations can be recorded as followings :

Table 21 1

Temperature=25°C, Atmospheric Pressure=p pascal Cross section area of the syringe =Am², mass of the piston=M_1 kg

S. No	*Mass kept over the syringe M, kg.*	*Volume of the entrapped air V, m^3*	*Total pressure, P* $\left\{\left(\frac{M+M_1}{A}\right) g+p\right\}\times 10^{-3}$ *kPa*	*P × V, kPa. m^3*
1				
2				
3				
4				

N B. . 1 atmospheric pressure=1.01×10^5 Pa=1.01×10^2kPa. 1 cm^3=$10^{-6}m^3$ (for illustration, most of the quantities are expressed in SI Units)

With the help of data, ask the students to plot a graph and show that

$$V \propto \frac{1}{P} \text{ or } V=\frac{k}{P} \text{ or } PV=k \text{ (constant)}$$

In the above equation, there are two variables, V and P.

As such, equation, $V=\frac{k}{P}$ will be an equation of straight line. Now if by plotting a graph between V and $\frac{1}{P}$ pupils get a straight line, it proves that volume is inversely proportional to pressure (Figs. 21.2 and 21.3).

(The generalization is based on the data obtained during experimentation. This approach is called *discovery approach*). In many instances, it is not possible to get the expected result. This may be due to some discrepancy in collection of data on which the generalization is based. In the above demonstration the following precautions should be taken :

1. There should be no friction between piston and internal wall of the syringe.
2. The nozzle of the syringe should be made air tight.
3. Mass of the piston and mass kept

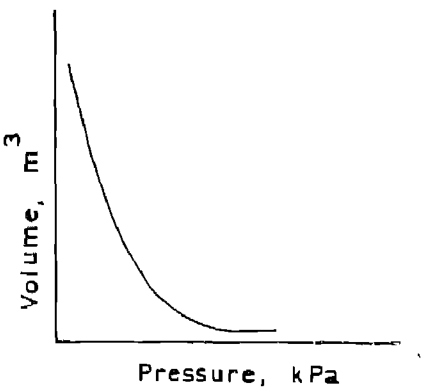


Fig. 21 2. A plot of V between P

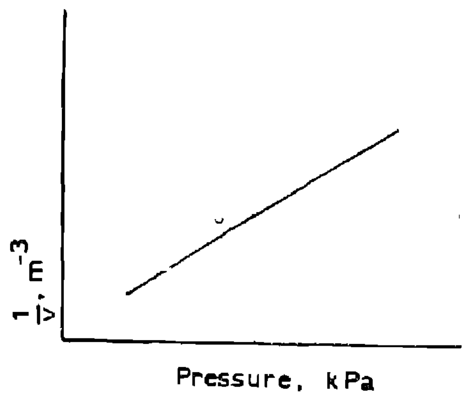


Fig 21 3 A plot between P and $\frac{1}{V}$

It would be relevant to point out that after plotting a graph between V and P, and also between V and $\frac{1}{P}$, let the students themselves generalize and write the relationship in the form of an equation

over the piston multiplied by 'g' will give actual weight of the plunge In order to find out the total pressure, one should add all the three factors.

Demonstration-2

Material and Apparatus

Capillary tube of about 25 cm length

and approximately 1 mm diameter, mercury, meter scale, aeraldite, syringe for filling mercury.

Procedure

Insert mercury with the help of a syringe in a 25 cm long glass capillary upto a length of about 14 cm. Close one end of the capillary tube by using aeraldite, keeping the capillary in a horizontal position. This, in fact traps air between the close end and mercury column. Now if the open end of the capillary is raised keeping the close end in contact with the surface, weight of the mercury applies pressure on the entrapped air (Figure 21.4).

Precaution : During the experiment if any mercury is spilled, it should be very carefully collected.

Take different readings for the volume of air trapped and the height of the mercury column. When the tube is held horizontally, the pressure of the trapped air is the same as the atmospheric pressure. However, when the tube is vertical, the mercury column in the tube either adds to the atmospheric pressure (open end up) or subtracts from it (open end down). Take different readings by keeping the tube in different positions. Observation may be taken as following (The Table 21.2 provides with sample data is provided).

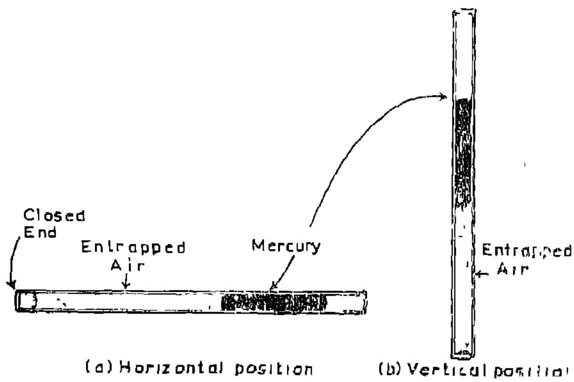


Fig 21 4 Verification of Boyle's Law

Table 21.2

Sample data

S. No.	*Volume* of entrapped air in terms of height (x cm)*	*Atmospheric pressure (cm Hg)*	*Vertical height of mercury column (cm Hg)*	*Pressure of entrapped air, P (cm Hg)*	*P × x*
1	7.8	75.2	0	75.2	586.6
2	6 8	75.2	11 1	86 3	586.8
3.	9 1	75.2	11 1	64.1	583 3

*Height × cross section area = volume. Here the cross section area is constant, therefore height ∝ volume.

This demonstration may also be considered as *pupils' experiment* if two to three capillary tubes and mercury for the filling of the tubes is available

In all such demonstrations there should be active participation of the students.

During this type of experiment, students may be interested to know atmospheric pressure and how it is measured. Please show them a barometer and explain different units of pressure.

$$\begin{aligned}\text{Pressure of 1 atmosphere} &= 76 \text{ cm of Hg or } 760 \text{ mm of Hg}\\ &= 1.01325\times 10^{5} \text{ Pa (Pascals)}\\ &= 1.01325\times 10^{2}\text{kPa}\\ &= 29.921 \text{ inches Hg}\\ &= 760 \text{ torr}\end{aligned}$$

Kinetic Model for a Gas

So far you have dealt with various properties of the gases. In the present section, you will consider a scientific model for explaining the behaviour of a gas. In this connection, you will make use of the situations which are known to pupils. Taking suitable analogies, you may illustrate new ideas and stimulate the pupils imagination.

It is not possible to see the particles present in a gas but on the basis of the observed behaviour (macroscopic properties of the gases) you can have a mental picture of the structure of a gas (i.e. idea of microscopic setup). *A model, which is a concept by making a deliberate analogy with a more familiar idea can be generalized, extended and tested, and if necessary can be further modified.* The Model used to verify other properties of the gas if found to be correct, means the model is valid widely and can be generalized.

A more abstract regularity, expressing a hidden likeness is generally called a model. The model systematizes our experimental knowledge.

In the present context, you will talk of various experimental observations regarding the behaviour of gases. Show a few experiments to your pupils to make them familiar with certain properties. Also if possible let the students perform certain experimental activities.

1. Gases exert pressure

Activity Blowing of balloon by pupils. The gas being blown will be pushing on the inside of the balloon stretching its elastic wall.

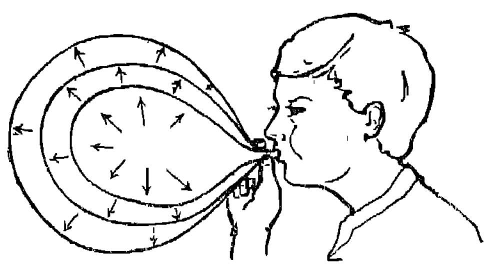


Fig. 21.5(a). Blowing of a balloon

2. *Gases occupy the total volume available to them*

Activity—Inject NO_2 gas enclosed in a syringe into a gas jar fitted with lid The entire jar becomes brownish.

3. *Gases are highly compressible*

Activity—Fill the air in a 500 ml syringe as shown in Figure 21.1. Now close the nozzle of the syringe and press the piston by putting weights on the platform raised over the piston. Show the result to the pupils. (Cycle tube and basket ball contain compressed air, what happens if these containers are too weak to withstand the pressure ?).

4. *Gases expand on heating*

Activity—Set up an apparatus as shown in Figure 21 5 (c). Put the glass bulb fitted with a long glass tube in a water bath.

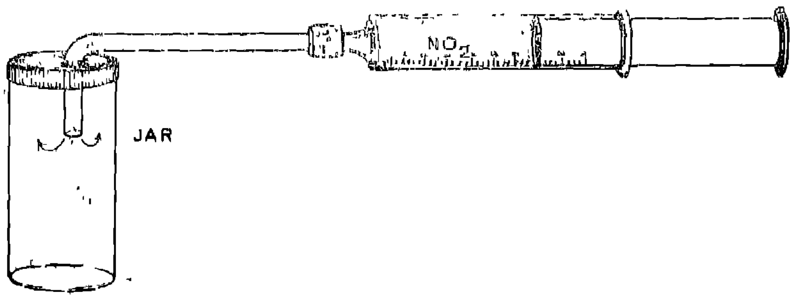


Fig. 21.5 (b) Diffusion of gases

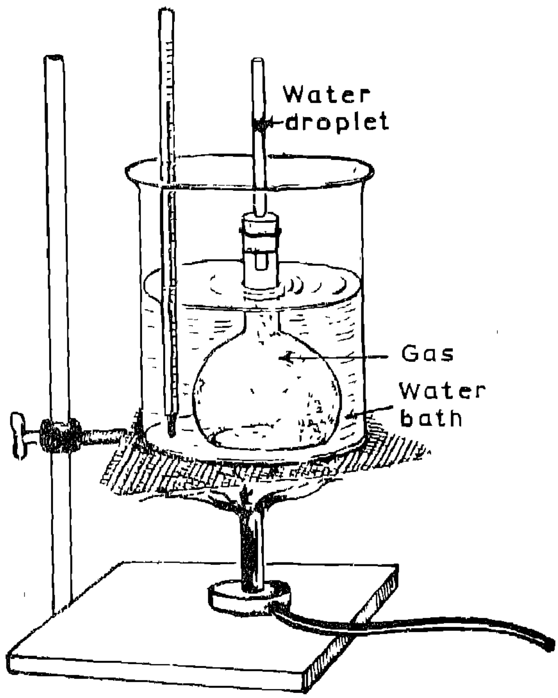


Fig. 21.5 (c). Effect of temperature on volume

Entrap a water droplet in the glass tubing. Raise the temperature of the bath slowly. Note the movement of the droplet. Take the reading at various temperatures and show the effect of temperature on the volume of the gas.

5. Gases diffuse and different gases diffuse at different rate

Activity—Allow H_2S or NH_3 gas to go out of the apparatus being prepared at one corner of the room and let the pupils sitting at the other corner of the room have the experience of the smell of the gas. (Odour of the vaporised perfume is clearly detectable across a room) For showing the difference in rates of diffusion show the experiment indicated in Figure 21 5 (d) which gas diffuses quicker, HCl or NH_3 ?

The answer of these questions probably lies in the 'structure' all the gases have and here you will try to form a mental picture of that structure The process of constructing a mental picture of this kind is called forming a theory and the structure you imagine is generally called a 'model'. In order to evolve a model for a gaseous state to explain their properties, you have to take several important properties all gases have in common and imagine the kind of internal structure a gas must have to display these properties For convenience, prepare four columns, first for observed behaviour, second to summarize the thinking involved in connection with it, third for summarizing the statement or postulate of the evolving theory and fourth for suitably presenting analogies and illustrating abstract thinking. After showing the properties of the gas as

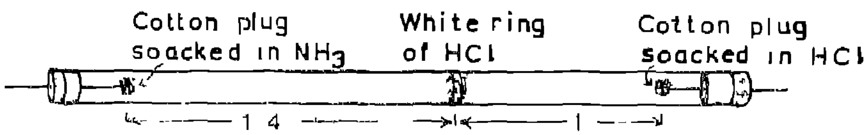


Fig. 21.5(d). Diffusion of gases

Now after demonstrating some of these properties, put the following questions

(i) Why gases occupy the entire space available to them ?

(ii) Why gases are highly compressible ?

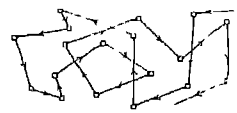
(iii) How gases exert pressure ?

(iv) Why different gases diffuse at different rates ?

(v) Why does heating a gas cause it to expand ? etc, etc

given earlier in this section help the pupils to give reasoned thought and suggest suitable postulates and therefore for evolving a model.

Now systematically write down the postulates which are obtained as a result of logical thinking based on the experimental behaviour of the gases. On the basis of postulates, derive the mathematical theory which is popularly known as *kinetic molecular theory*. The specific word 'kinetic' attached to the theory indicates that

Observed behaviour	*Thinking/ Imagination based on logic*	*Postulate*	*Analogies/illustrations of thinking relating the postulates*
Gases expand without any apparent limit	For this behaviour to be possible the internal structure of a gas must be discontinuous i.e. composed of small pieces	1. All gases are made up of minute particles Let us call them molecules (In a few cases these particles are atoms also).	If it were continuous, infinite expansion would not have been possible, A continuous fabric can be stretched to a certain limit. In case of continuity similarly there would have been a limit of expansion.
Gases diffuse and during this process move from one place to another	If the particles are in motion they can move from place to place. Since gases move in all directions, the motion of the particles must be in all directions.	2. The gas molecules are in constant chaotic motion.	Robert Brown observed under a microscope that pollen grain performs zigzag motion Smoke particles can also be seen moving. Molecules which are much smaller, are expected to move more violently. 
Gases are highly compressible	This will be possible if there is a tremendous amount of empty space available in the gas. Under this situation, the molecules which are considered far away from each other can be pushed closer and closer.	3. The molecules are very small compared to the distances between them.	The average spacing between the molecules of nitrogen at STP is worked out to be about ten times the molecular diameter; when the gas will be compressed the average spacing between the molecules will be reduced.
The gas exerts a pressure, that is a force on the walls of the container.	It could be explained on the basis of moving particles if the particles bombard the wall, exerting force somewhat like that produced by a stream of machinegun bullets striking a target.	4. Pressure results from the bombardment of the walls of the container by the moving molecules.	Molecules may be considered like billiard balls striking the wall of the container with a speed of bullet. The magnitude of the pressure will depend upon the rapidity of the bombardment, number of collisions with the wall of the container occuring in unit time, and the force with which molecules strike

(Contd.)

The pressure remains constant over long periods of time, if the temperature, volume and amount of the gas remains constant.	The average speed and average kinetic energy of the particles must remain constant under these conditions, even though collisions between particles must be occuring constantly.	5. No energy is lost by molecules as a result of collisions, that is all collisions between the molecules and between the molecules and the walls of the container are elastic. (Elastic collision can occur only when there are no attractive or repulsive forces between the molecules).	If there were loss of kinetic energy, motion of the molecules could eventually stop and pressure and temperature would drop to zero Since pressure of the confined gas does not change with time (unless one heats or cools it), it can be concluded that gas exerts pressure through elastic collisions with the walls.
At constant volume, the pressure of a definite mass of gas is directly proportional to the absolute temperature.	For the pressure to increase, either the frequency of collision with the wall must increase, or else the force of each collision must increase, or both. Since the mass of the molecules changes with change in temperature, one can guess that the velocity of the moving molecules changes. However, if the velocity were proportional to the temperature, both the frequency of collision and force of collision would change and pressure would increase as the square of the temperature To make the pressure proportional to the first power of the temperature which is an experimental truth, the velocity must be proportional to the square root of the temperature, i e. $v \propto \sqrt{T}$ or $v^2 \propto T$	6. The kinetic energy $1/2\ mv^2$ is proportional to the absolute temperature i.e. $\frac{1}{2}mv^2 \propto T$ or $\frac{1}{2}mv^2 = \text{constant} \times T$.	As molecules collide with each other, we would expect the velocity of the molecules to change. All the molecules therefore will not have the same velocity at any time. Therefore kinetic energy will be average kinetic energy which is fixed at constant temperature. Change in temperature will change average kinetic energy. It is not possible to determine the velocity or kinetic energy of individual molecule. Statistically one can predict how many molecules have a particular velocity and kinetic energy. Distribution of velocity of the molecules at a particular temperature can be given by Maxwell Boltzmann-distribution law.

molecules which are present in gases are not stationary but moving. With the help of a model, it is possible to get a relationship between the pressure exerted by the molecules, the velocity (root mean square velocity), mass of the molecules and volume of the gas.

This relationship is expressed as .

$$PV = 1/3 \ mnv^2$$

Using the above equation, it is possible to derive Boyles' law, Charles' law, Avogadro's law, Dalton's law of partial pressure, etc. dealing with gases A 'Kinetic' molecular model of a gas is shown below.

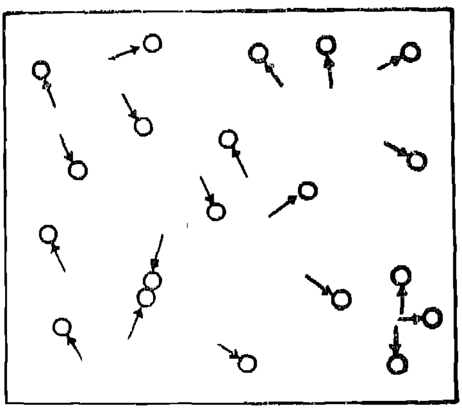


Fig. 21 6. Kinetic molecular model

Test for Pupil Evaluation

1. Define the following :
   (*a*) Boyle's law
   (*b*) Charle's law
   (*c*) Avogadro's law
2. Why is gaseous form more compressible as compared to the liquid and solid forms of the same substance ?
3. Differentiate solids, liquids and gases on the basis of kinetic model.
4. What is an ideal gas equation ? Is it applicable at all temperature and pressure ? Explain on the basis of kinetic model.
5. The volume of nitrogen gas at 23°C and 800 mm Hg pressure is 100 cm^3. Calculate the volume of the oxygen at STP.
6. A gas with a volume of 4 litres is cooled at constant pressure from 1000°C to 0°C. What volume will it occupy now ?
7. 100 cm^3 of a gas is filled in a cylinder fitted with a piston at 10°C. If the temperature of the gas is doubled, keeping the pressure constant, the resulting volume of the gas will be :
   (*a*) 50 5 cm^3
   (*b*) 207 cm^3
   (*c*) 103 5 cm^3
   (*d*) 108.5 cm^3
8. Outline the basic assumptions of kinetic molecular theory as applied to the gases How is the average kinetic energy related to absolute temperature ?
9. Write short notes on the following :
   (*i*) diffusion
   (*ii*) molar volume
   (*iii*) kelvin temperature
10. Give reason for the following :
    (*a*) The tyre of an automobile is inflated to a slightly lesser pressure in summer than in winter.
    (*b*) The size of the weather balloon becomes larger and larger as it ascends to higher altitude

Method Used

What method will you use in teaching this chapter to your pupils ? In this chapter,

you can develop most of the concepts through demonstrations followed by discussion. The most important aspect which is to be emphasised in this unit is 'improvisation' Most of the apparatus used for demostration in this chapter is improvised. Improvise some more apparatus for verifying various gas-laws and also encourage the students to do so. In improvisation make best use of your laboratory facilities and local resources It is further emphasised that for teaching this chapter, *inductive approach*, as mentioned earlier, should be followed. Here students can very easily generalise the principles with the help of the data obtained In collecting data with improvised apparatus, there is need for taking all the possible precautions for getting reliable data.

The main aspect which was to be dealt in this chapter was to have a model for a gas. In what way the approach of this chapter is different from the 'model' for an atom ? In both the cases, you have thought of model. Here model provides a simplified picture of molecules present in a gas. This part of the chapter has special significance from the present teaching point of view. We can not make the students think of the abstract situation when molecules of a gas are in motion interacting with each other. By taking suitable analogies like billiard ball, we can easily make the students visualise the situation in which molecules are moving and interacting with each other. A 'model' is based on the properties you study and, therefore, validity of the model can be tested if necessary, and can be further modified to have a generalised picture. Can you think of some other 'models' on this pattern ? Prepare an effective teaching plan for your lesson.

Assignments

1. Take a J-shaped glass tube closed at one end and open at the other end. Fill mercury and trap air as shown below. By adding further mercury in the longer column, verify Boyle's Law.

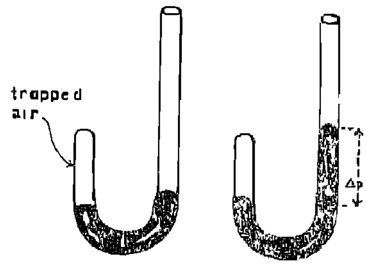


Fig. 21.7 Apparatus for the verification of Boyle's Law

2. One mole of any gas irrespective of its molecular size and weight occupies 22.4 litre of volume at STP. Discuss the truth in light of kinetic molecular model.
3. Derive the mathematical expression PV=nRT using the model of the gas. Under what conditions the equation will be valid for a gas.
4 Consider a model for a gas in which you assume the molecules have appreciable volume and also there is intermolecular force. Suggest an equation of the state of such a gas.
5 Set up an apparatus to show variation of volume with temperature for a given mass of a gas at constant pressure, and collect the data. Plot volume vs temperature and develop the concept of kelvin (absolute) temperature.
6. Discuss various gas laws in the light of kinetic molecular model of

the gas you have evolved.

7. In order to give a clear-cut understanding of the ideal and real gas what sort of lesson plan will you prepare ?

8. For the distribution of velocity at a particular temperature take the analogy of marks obtained by students in an examination and discuss distribution of marks with your pupils. Do you consider this would be a suitable analogy ?

ask the pupils to work out a kinetic model for liquids and solids

Solids

(*i*) Solids are rigid and have definite shape ;
(*ii*) Solids maintain their volume ;
(*iii*) Solids are nearly incompressible ,
(*iv*) Solids diffuse very slowly as compared to liquids and gases.

Liquids

(*i*) Liquids have no definite shape ;

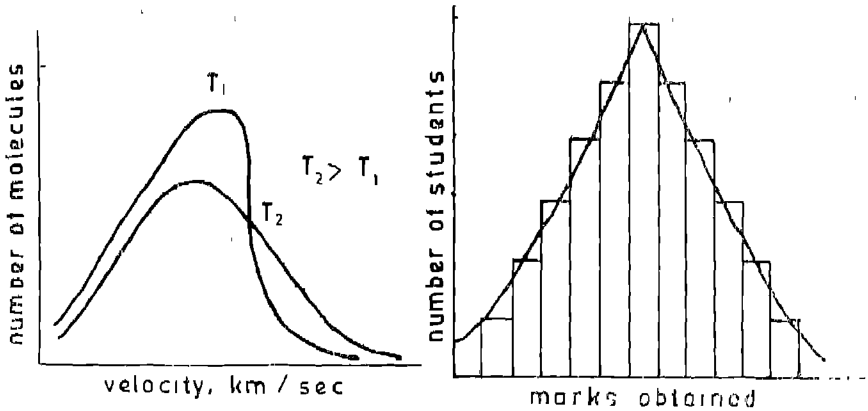


Fig. 21.8. Distribution of velocity and marks versus number of molecules and number of students respectively

9. Devise an apparatus to measure partial pressure of a gas.

10. Derive the equation, $PV=nRT$, with the help of Boyle's law, Charle's law and Avogadro's law. Give numerical problems to the pupils based on the above equation. Also cover some of the problems related to 'mole concept' already covered in Unit I.

11. Demonstrate some of the properties of the solids and liquids which are feasible in classroom situation and

(*ii*) Liquids maintain their volume ;
(*iii*) Liquids show little change in volume with change in temperature and pressure ;
(*iv*) Liquids evaporate ,
(*v*) Liquids show surface tension and viscosity.

12. Explain to your pupils the behaviour of a gas which consists of miniature billiard balls bouncing around in a container endlessly, making elastic collisions with the walls.

13. Note the following and practice :
    (*a*) In the present Unit, there is a lot of scope for experimental work, let the pupils design themselves the apparatus for verifying Boyle's law, Charle's law and other gas laws wherever feasible.
    (*b*) Important characteristic properties of gases, liquids and solids should be emphasised in daily life.
    (*c*) Skill for measuring temperature and pressure should be developed at this stage.
    (*d*) Preparation of models, charts, etc. should be encouraged in those cases where it is not possible to perform experiments for demonstration work.

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FILMS

1. 'Gas laws and their applications', 14 mm black and white (Encyclopaedia Britannica film).
2 'Gas pressure and molecular collisions', 21 mm black and white Chem. Study film.
3. 'Behaviour of gases', 15 mm PSSC film.

CHAPTER 22

Oxidation and Reduction

Introduction

There are several ways of classifying chemical reactions One of these is to group them under either redox or non-redox reactions. We shall be discussing here the important features of redox reactions because such reactions play a significant role in biological system and many industrial processes. The expansion for the term redox is *reduction-oxidation.* Our views about these reactions have undergone considerable changes over the years. The earliest definition of *oxidation* for instance was that it was a reaction in which either oxygen was added to or hydrogen removed from a species and *reduction* was the reverse of oxidation Our understanding of the structure of atoms reveals that in most of these reactions there is a clear transfer of electrons from one species to another. Possibly this feature, namely transferring electrons from one species to another, characterises redox reactions. It follows that in these reactions one species should be able to give up electrons and another to accept them Now the question arises whether a given substance which is found to lose electrons to a particular substance in reaction will also exhibit this tendency with respect to all other substances? Can this ability on the part of substances to involve themselves in the transfer of electrons be used for producing electric energy. In what way these redox reactions are useful in our everyday life and industries. These are some interesting questions that can be raised in the present context and discussed in the present chapter.

Major Ideas/Concepts

1. The reactions involving transfer of electrons from one species to another are redox reactions

   Oxidation means removal of electrons from and reduction addition of electrons to a species.

2. Oxidation number is the charge that an atom has or appears to have when combined with other atoms. Oxidation is increase in oxidation number and reduction is decrease in oxidation number.
3. Redox reactions can be used for the production of electric energy.
4. Redox reactions are of vital importance in our daily life and industries.

Objectives

1. To define redox reactions in terms of electron transfer and oxidation number.
2. To classify a given set of reactions into redox and non-redox reactions.
3. To calculate the oxidation number of a specified atom in a compound/ion given the oxidation numbers of the other atoms in combination.
4. Given a set of reactions involving elements, to arrange specified elements in the increasing order of their ability to undergo oxidation.

Development of Concepts Through Activities

Two concepts from the list given above are chosen here to illustrate possible methods of development. One of them is sought to be developed by a *teacher demonstration* and the other by *group activity*, both being followed by a *discussion*.

Oxidation involves removal of electron(s) from a species and reduction involves addition of electron(s) to a species. (The species which loses electron is said to be oxidized and one that gains electrons is said to be reduced).

Demonstrate the following experiments :

Dip strips of different metals [Cu, Zn, Pb, & Fe] in every one of the metallic salt solutions [$CuSO_4$, $ZnSO_4$ $Pb(NO_3)_2$ & $FeSO_4$] and ask the pupils to note changes, if any, on the surface of the metals and in the solutions.

The table below indicates the observations in the case of zinc. Complete the table in other cases also.

Table 22 1

Metals	*Aqueous Salt Solutions of*			
	$CuSO_4$	*$ZnSO_4$*	*$Pb(NO_3)_2$*	*$FeSO_4$*
Zn	Appearance of a red deposit on Zn strip and gradual disappearance of blue colour of the solution	No change	Dark-grey deposit on zinc strip	Brown deposit on zinc strip
Cu	....	....	....	....
Pb	....	....	....	....
Fe	....	....	....	....

Discussion

You have listed a number of observations in Table 6 1. These need to be interpreted in terms of our previous knowledge about the nature of the substances involved. This can be done by raising a series of questions which should lead to the establishment of the following links :

Expected inferences

deposit of Copper on zinc
removal of Cu^{2+} from solution
$Cu^{2+}(aq)+2e^{-} \rightarrow Cu(s)$
removal of electrons from zinc
$Zn(s) \rightarrow Zn^{2+}(aq)+2e^{-}$
$Cu^{2+}(aq)+Zn(s) \rightarrow Zn^{2+}(aq) +Cu(s)$

Observation/Questions raised

Red deposit on zinc
Discharge of blue colour of solution
What change has Cu^{2+} undergone ?
What is the source of electrons ?
What change has Zn undergone ?
Write the overall reaction between Zn and Cu^{2+}

Similarly, establish the relationships in the other cases. The common feature in all these reactions is inferred to be a transfer of electrons from one species to another The species that loses electrons has undergone oxidation and the species that gains electrons has undergone reduction. Such reactions are called redox reactions.

Note on methodology adopted :

As detailed above, this is a demonstration followed by discussion technique The initial part of the development requires observation of experiments and tabulation of the results The more crucial part of the development follows where the students are encouraged to interpret the results in terms of their knowledge of atomic and molecular structure of the substances involved Interpretation is then followed by a generalization about the characteristic feature of a redox reaction

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Redox reactions can be used to produce electricity.

In the experiments where metal strips were dipped in various metallic salt solutions, we have found that reaction (such as deposition of metals, change in colour of solution, etc.) occurs in some combinations only. We have explained this by proposing that there is transfer of electrons from one species to another. These were defined as redox reactions Note that in these cases oxidation and reduction occur simultaneously and at the same site (For instance, when a zinc strip is dipped in $CuSO_4$ solution copper deposits on zinc and zinc goes into solution as Zn^{2+}). Let us alter the arrangement so that the two reactions occur at two different sites This may be accomplished by undertaking the following investigation :

Investigation

The following investigation is distributed among the students, so that each group will be making observations in respect of one combination of half cells. The students will carefully record their observations and bring them for a class discussion at the end.

Prepare approximately 0 1 M solution of the following salts $MgSO_4$; $Al(NO_3)_3$, $ZnSO_4$, $FeSO_4$, $SnCl_2$, $Pb(NO_3)_2$ and $CuSO_4$ Take these solutions in different beakers and in each solution dip strips of the corresponding metals. Here each assembly of a metal strip dipped into solution of

its salt, is called a 'half cell'. Prepare a saturated solution of KCl and soak a number of strips of filter paper in it

Connect the $Zn/ZnSO_4$ half cell to the negative terminal of a voltmeter. Connect each one of the other half cells (viz. $Cu/CuSO_4$, $Pb/Pb(NO_3)_2$ and so on), to the positive terminal in turn Dip one end of the filter paper soaked with KCl in the $ZnSO_4$ solution and the other end in the other metallic salt solution. The assembly of the combination of the two half cells will be as shown in the figure. Note the voltage if any If needle of voltmeter does not show any deflection from left to right in any of the cases, connect the zinc strip to the positive terminal and the other metal to the negative terminal.

2 Similarly arrange the other set of half cells, where Zn was connected to the positive terminal in the increasing order of voltages.

3 Explain why you could measure a voltage in each case

4. Write the equations for the reactions in each half cell.

5. Why was it required to connect Zn to the positive terminal in some cases ?

You have seen that in the above investigation the source of electricity is redox reaction. You take some more investigations of the type given below which will further help you in strengthening the understanding of the above concept.

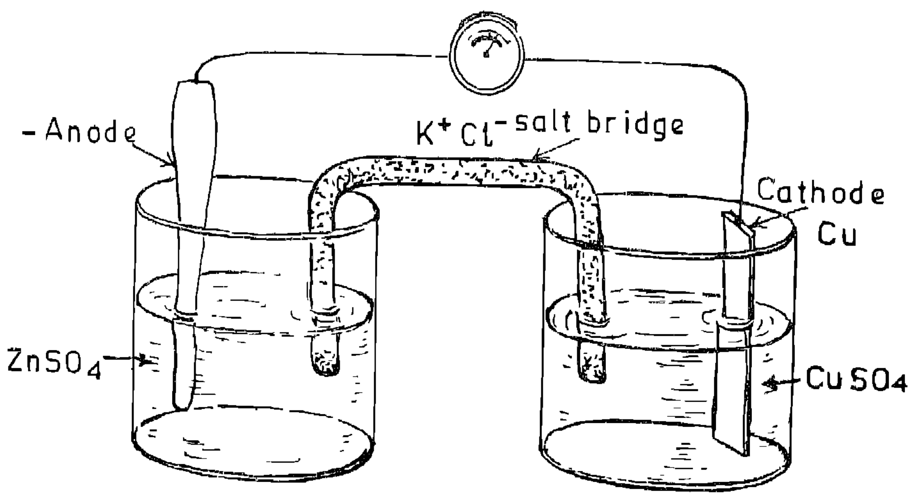

Fig. 22.1. Setting of a galvanic cell

Discussion of the observation may be undertaken with reference to the following guidelines and questions.

1. In the cases where Zn was connected to the negative terminal, arrange the half cells combined with the $Zn/ZnSO_4$ half cell, in the increasing order of voltages measured

Method Used

What method will you adopt in teaching the chapter to school pupils? First, you demonstrate the redox reaction and write the chemical equation. Here students apply their *previous knowledge* of atomic structure to understand the nature of oxidation-

reduction. Instruct the students to carefully observe the demonstration experiments and tabulate the results properly for reaching a particular generalisation. What other method can you adopt for teaching ? Do you feel students should be given project based on the concept covered under this chapter ? Charts will be useful for this chapter

If $Al/Al(NO_3)_3$, is the half cell connected to the negative terminal of the voltmeter, which other half cell will, on combination with $Al/Al(NO_3)_3$, give the highest voltage ? What would be the order of increasing voltages ?

Assignment

1. Prepare a self-instructional material to develop the concept of oxidation number In the beginning you may point out, why there was a need for introducing oxidation number. Prepare a chart of rules for determining the oxidation number.
2. Suggest a suitable set of activities which could be used to develop the concept "metals differ from one another in their abilities to undergo oxidation".
3. The teacher has demonstrated the reaction between a solution of KBr and Cl_2 water. What could be an appropriate sequence of questions to show that chlorine has functioned as an oxidizing agent in this reaction ?
4. Use a spent dry cell for improvising an electro-chemical cell. Try a variety of electrolytes and find out which will give the highest voltage.
5. Collect examples of oxidation reduction from everyday life and industries. Ask your students to prepare charts and show the various processes pertaining to the redox reactions (Hint-redox processes for sustaining and controlling life, photography and respiration, obtaining energy from fuels, chlorination of water used for drinking, extraction of metals from their ores, electroplating, and electrorefining, photography, explosives, etc.

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CHAPTER 23

Chemical Kinetics

Introduction

You are aware that when chemical reaction occurs, energy changes take place. For example, when coal or petrol burns, tremendous amount of heat is liberated. Here it will not only be important to know that energy is released during a chemical reaction but it will be equally important to know how rapidly it occurs, i.e. whether that energy will be released immediately or over a period of minutes, days or months. In other words it is necessary to know *how fast* a chemical reaction occurs. The study of the rates of chemical reactions is known as *chemical kinetics*.

You might have seen that a candle remains inert in contact with air for any length of time but it reacts on coming into contact with a lighted match. Similarly, petrol and its vapour can remain in contact with air for almost an infinite stretch of time provided that no spark ignites the mixture. Now the question arises, why is sparking needed for initiating the burning? Since we recognise the importance of being able to control rates of various processes such as spoilage of food, combustion of fuel etc., therefore, it would be quite profitable to understand the factors like concentration, temperature and presence of catalyst that control the speed of a chemical reaction. This unit is intended to help you to revise your understanding of basic concepts of chemical kinetics and to give you a suitable method for teaching them effectively.

Major Ideas/Concepts

(*i*) Rate of chemical reaction can be expressed in terms of the variation in concentration of a reactant or product with time.

(ii) Rate of a chemical reaction increases with concentration of the reactants

(iii) Energy of activation is the threshold energy, Ea, necessary to permit a reaction to occur.

(iv) Enhancement in reaction rate with increase in concentration is due to increased number of collisions between reacting molecules in unit time and in unit volume.

(v) Rise in reaction rate with temperature is due to increased fractions of molecules possessing energy equal to Ea (energy of activation).

(vi) Catalysts increase the rate of a reaction by providing an alternative mechanism of lower activation energy.

Concept Development through Activities

1. *What is the rate of a reaction ?*

In order to teach this concept, you have to demonstrate the following experiments :

(i) Reaction of aluminium plate with 0.5M NaOH

(ii) Dissolution of marble chips in 0.5M HCl solution.

Experiment No. 1. Reaction of Al plate with 0.5M NaOH

You know that H_2 gas is one of the products in this process and, therefore, the progress of the reaction can be followed by measuring the amount of hydrogen coming out of the reaction vessel

Take about 30 ml NaOH solution in the reaction tube as shown in Fig. 23 1 and add an Al piece of 1 0×5 cm dimension Stopper the tube properly and ensure that there is no leakage. Collect the hydrogen gas through the delivery tube in a graduated tube by water displacement method. Instruct your pupils to record volume of the gas in the graduated tube after 2, 4, 8, 12, 20 and 30 minute intervals. You may also record these values on the blackboard (as per table provided).

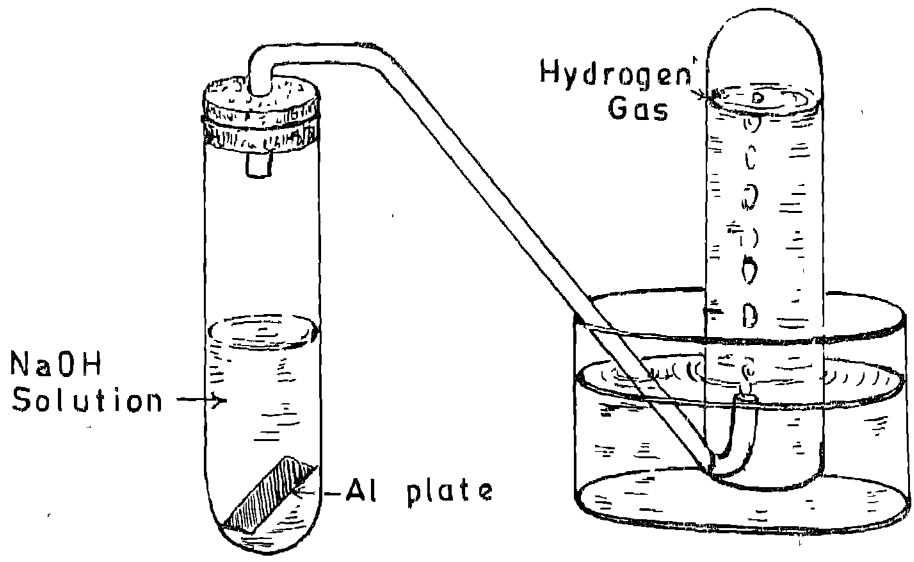

Fig. 23.1. Study for rate of reaction

Table 23 1

S. No	Time (Min)	Volume of the hydrogen gas collected (ml)
1	2	—
2	4	—
3.	8	—
4.	12	—
5.	20	—
6.	30	—

Now plot the gas volumes against the corresponding time intervals on a graph-board. Tell your pupils also to do the same on a sheet of graph paper.

Now ask the following questions.

1. **What is the nature of plot between the gas volume and time ?**
2. **Can you determine the rate of hydrogen evolution from this graph at a particular time ?**
3. **Do you expect the plot to pass through the origin ? If so, can you give the reason ?**
4. **What inference can you draw from the shape of the curve ?**

Now find out the slope of the plot at different points. Explain the difficulties in measuring the slope when the plot is non-linear. How can they determine the rate of reaction at any instant of time by drawing a tangent at the corresponding point on the plot ?

Now ask the pupils to draw tangents at three points and determine the reaction rate corresponding to these time intervals. Let them tabulate the three values of the reaction rate and check if they are identical Put a few questions on the time dependence of reaction rate.

Experiment No. 2 Dissolution rate of marble in HCl

This simple experiment can be easily used to give an idea of the rate of a chemical process.

You may prepare a simple apparatus as shown in Fig. 23.2.

Take about 20-25 ml of the dilute HCl and add a few marble pieces of nearly identical size. Now stopper your apparatus and clamp it vertically (as shown in Fig 23 2) Note the movement of acid solution in the side arm and when you find that it has reached to zero position of the scale, immediately start your stop-watch. Now ask your pupils to record the liquid level in the graduated side arm after 2, 5, 10, 15, 20 and 30 minute intervals. You may also record these values on the blackboard as indicated in Experiment No. 1.

Ask a few questions now.

1. **Why did you find the observed rise of the liquid level in the attached side arm ?**
2. **What will happen if you clamp the apparatus in reverse manner ?**
3. **Will you get any difference in values if the apparatus is not clamped exactly in vertical position ?**
4. **Can you suggest any other arrangement to measure the rate of CO_2 evolution.**

Instruct your pupils to plot the variations in liquid level against time duration. Ask some questions on the shape of the plot

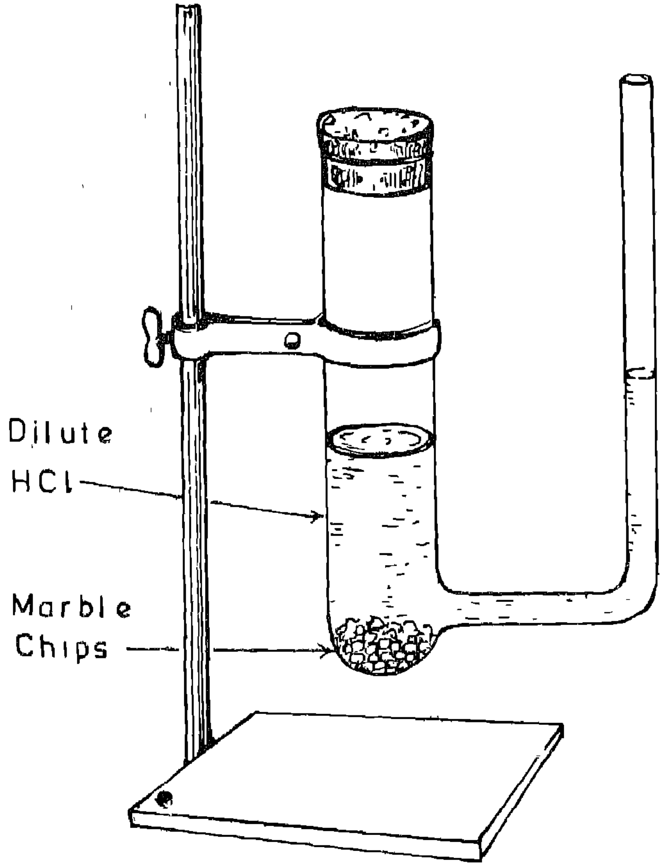

Fig. 23.2. Demonstration of rate of reaction

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1. **What is the shape of the plot ?**
2. **Is it linear or curved ?**
3. **Can you find out the rate of dissolution of marble from these observations ?**

From the findings of the above two experiments, you may explain how can they determine the rate of other reactions and how can they derive the definition of reaction rate from the experimental data. Also explain what unit has to be used in writing reaction rate.

2. *Temperature effect on reaction rate and activation energy*

Influence of temperature on reaction rate can be explained by demonstrating the dissolution of Al in 0.2 M NaOH at three different temperatures.

Regarding the experimental procedure, the methodology suggested in the previous section can be used. After recording the rates at three temperatures (room temperature, 40° and 60°C), ask your pupils to plot the three values of reaction rates against three different temperatures. After the

plotting is complete, ask a few questions on temperature dependence of reaction rate and shape of the plot.

Do you find any variation in reaction rate with temperature? What reason can you assign to the observed increase in rate with temperature? What is the shape of the observed plot? Can you plot these data in any other manner?

Now ask them to plot the reaction rates against the reciprocal of kelvin temperature. You also plot a similar graph on a graph board so that the pupils get an idea of plotting such results Now put few more questions·

1. **What is the shape of this plot?**
2. **Is it linear or curved?**
3. **Can you find out the slope of this plot?**
4. **What conclusions do you draw from this plot?**

The manner in which the rate of reaction varies with reactant concentration is expressed in the *rate law*, a mathematical expression between the rate and some function of concentration. For a general reaction $A+B \rightarrow C+D$ rate law can be written.

Rate$=k[A]^m [B]^n$

Here k is rate constant which expresses the proportionality between reaction rate and concentration of the reactants that appear in rate law. The values of m and n are determined experimentally and (m+n) will be the order of reaction. Now, can you write the rate law for the reaction?

$CaCO_3+2HCl \rightarrow CaCl_2+CO_2+H_2O$

Consider another reaction

$NH_4^+ + NO_2^- \rightarrow N_2+2H_2O$

(In practice NH_4Cl and KNO_2 or $NaNO_2$ are taken for the above reaction). Measure the evolution of N_2 gas and find out the value of k in the expression: Rate$=k[NH_4^+][NO_2^-]$ after measuring the rates of reaction at various temperatures. (For rate of reaction similar to measuring volume of CO_2, measure volume of N_2 at various interval of time. Plote graph between log k, and $\frac{1}{T}$, i e between logarithm rate of constant and inverse of kelvin temperature.) *What is the nature of the curve?*

For illustration you are provided data (value of k & T) for the reaction $2N_2O_5(g) \rightarrow 2N_2O_4(g)+O_2(g)$.

Table 23.2

S No	*Temperature Kelvin, T*	*k × 10⁵ (sec⁻¹)*
1.	338	487.0
2.	328	150 0
3.	318	49 8
4.	308	13.5
5	298	3 56
6	273	0.0787

Plot a graph between log k and $\frac{1}{T}$.

What type of graph do you get? In all such cases you will find a straight line Arrhenius found that equation of the line can be expressed as $\log k=(\log A - \frac{Ea}{2.3RT})$

Here k is rate constant, A is a constant (usually known as frequency factor, R is gas constant and Ea is energy of activation.)

Slope of the straight line will be equal to $-\frac{Ea}{2.30R}$. Energy of activation is the threshold energy for a reaction to occur. As you might have seen a gas does not burn unless it is sparked Sparking is done just to enhance the energy of the molecules and makes that equal to energy of activation before spontaneous burning starts.

With the help of data provided in Table 23.2 calculate the slope of the straight line for the reaction $2N_2O_5 \rightarrow 2N_2O_4 + O_2$, and calculate the energy of activation. Further, you supply more data (value of k at different temperatures) for various reactions and ask the pupils to calculate the value of Ea

3 Influence of catalyst on reaction rate

A catalyst is a substance which increases the reaction rate without being used up in the process, e.g. in Haber's process, the rate of formation of ammonia is greatly accelerated in the presence of an oxide. Catalyst only accelerates reactions that are already occuring. It participates in the reaction scheme in such a manner that in one step it is consumed but regenerated in the subsequent step.

To understand the action of the catalyst let us consider the situation in which a man is trying to roll a ball across a hill top so that the ball could reach another plane on the other side of the hill The bowler would have to provide certain minimum kinetic energy to the ball for this purpose. Now, if by some means, the height of the hill top is reduced, the bowler would have to provide lesser energy to roll the ball to the other side of hill and he will be able to roll more balls in a certain time interval.

We can think of a similar situation in case of catalysis. Somehow, the catalyst provides a low energy path between the reactants and the products and, therefore, more molecules get over the new energy barrier per unit time So the reaction occurs at a greater speed.

In fact, the catalyst provides a new reaction path for the formation of the products. The reacting molecules combine with the catalyst to form a different activated complex. The catalyst speeds up the reverse process also to the same extent as much as it speeds up the forward reaction. Furthermore, energy levels of the reactants and products remain unchanged and, therefore, no variation takes place in the heat of reaction, ΔH. In other words, a catalyst provides an alternative reaction path of lower activation energy for a chemical process.

To understand the influence of catalyst, perform the experiment on the decomposition of H_2O_2 at room temperature under the following conditions using the assembly shown in Fig. 23.1

(*i*) MnO_2 not present in reaction mixture

(*ii*) 1.0g MnO_2 taken in reaction mixture

(*iii*) 2.0g MnO_2 taken in reaction mixture

Test for evaluating pupils achievement

1. Does the rate of a chemical reaction change with the progress of the reaction, if so, what is the reason for this variation ?
2. Suppose you are given concentration of the reactants at various time intervals during a chemical change, can you calculate the rate value ?
3. What happens if you increase the

temperature of a reacting system ?

4. State several ways by which the rate of combustion in a candle flame might be increased. State the reason.
5. During the collision between the reacting particles, what is the primary factor that determines whether a reaction will occur ?
6. Sketch the potential energy diagram showing an endothermic reaction
7. State two variables that would increase the rate of a reaction and explain the reasons for the increase.

Method Used

What method of teaching do we adopt in teaching such topics in schools ? In the present chapter, concepts are to be developed with the help of demonstration, experiments and giving appropriate experiences of those reactions with which the pupils are familiar. It is easy to give demonstration on 'rate of reaction', 'effect of temperature', etc. However, there are still certain concepts like 'energy of activation' the importance of which can only be highlighted, and students can be motivated to learn through demonstration—but values cannot be determined directly. Can you think of any simple method for determining this ?

For effective teaching you have to consider various aspects like teaching style, methods adopted, innovative processes in teaching, question techniques, planning demonstration experiments, planning a class experiment, arranging group discussion and group activities, making best use of local resources and laboratory facilities, etc. For effective teaching, prepare a complete plan of this topic and try to incorporate all the mentioned components.

Assignments

(i) Prepare a chart showing different stages of the chemical reaction between H_2 and I_2 molecules.

(ii) Fabricate an assembly to measure the rate of decomposition of H_2O_2.

(iii) Prepare a chart showing the potential energy barrier curve for exothermic and endothermic reactions.

(iv) Suggest a simple experimental set-up which can be used to find out the dissolution rate of some powdered substances.

(v) Prepare a chart showing how the energy of activation is lowered in the presence of catalysts.

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CHAPTER 24

Chemical Equilibrium

Introduction

You have read that in the manufacture of NH_3 from N_2 and H_2 by Haber's process, whole of the nitrogen present in the reaction system cannot be converted into ammonia in spite of taking excess quantity of H_2. Concentrations of H_2, N_2 and NH_3 acquire some steady value, depending on temperature and pressure. It is also known that on heating ammonium chloride in a closed vessel, some amount of the undecomposed compound is always left which does not change further. Similarly, if you keep water in a closed cylindrical glass vessel for a few days, you will find that the water level decreases initially and after some time attains a steady value. You come across many other such processes in which it is not possible to convert the reactants into products completely. A question, therefore, arises why a system approaches to a state of no-change or equilibrium wherefrom no further variation occurs in concentration of the constituents present. The study of this state of equilibrium and the various factors that affect this state come under the domain of this unit.

Objectives

1. To understand the significance of equilibrium state in a chemical process;
2. to develop an understanding of the various factors which affect equilibrium state;
3. to enable pupils to predict the yield of various products in a chemical process under a particular set of conditions;
4. to realize the importance of equilibrium state in day-to-day life.

Major Concepts

1. Majority of the physical and chemical processes are reversible in nature.
2. In a reversible process, state of equilibrium is attained when rates of the forward and reverse processes become equal.

3. State of a chemical equilibrium is recognised by the constancy in Macroscopic properties of the system.

4. Chemical equilibrium is a dynamic process

5 Equilibrium state is affected by a number of factors like pressure, concentration, temperature, etc.

6. Equilibrium constant is indicative of the extent to which a reaction can occur.

(In order to teach chemical equilibrium, an understanding of the above-mentioned points is very essential. You are, therefore, advised to consult Chapter 9 ref. 2 and Chapter 12 of ref. 4).

Concept Development through activities

Let us now discuss the approach which can be adopted to teach concepts 1 and 3 effectively.

Reversible reactions

In order to teach this concept, demonstrate to your pupils the colour changes which occur on dipping blue and red litmus paper in acid and alkaline solutions and tell them to record their observations. Then ask a few questions on the colour changes that occured in litmus papers.

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1. **What colour did you notice on dipping blue litmus paper in acidic solution ?**
2. **What happened when the acid-dipped blue litmus paper was put in alkaline solution ?**
3. **What do you expect on doing a similar experiment with red litmus paper ?**
4. **Why do you find reappearance of blue colour on dipping red litmus paper in alkaline solution ?**

Now take about 20 ml of water in a beaker and add 2-3 drops of phenolphthalein indicator. Show your pupils the colour changes occuring in this solution on adding small quantities of acid and alkaline solutions of nearly equal strengths If possible, tell them to do their own experiment and record their observations. Ask a few questions in connection with these colour changes and the reactions occuring under different stages.

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1. **Why do you get pink colour on adding alkali to the solution kept in beaker ?**
2. **What happened on adding acidic solution now ?**
3. **What change may occur in solution colour on adding alkali again ?**
4. **What conclusion can you draw from the following colour changes.**
   Pink→Colourless→pink or
   Colourless →pink→colourless

On the basis of the above experiments, explain to your pupils that the reappearance of pink colour in the phenolphthalein containing solution or in the case of litmus papers is due to the reversible nature of the reactions (changes) in these systems.

You can further clarify this concept by demonstrating the colour changes occuring in NO_2 gas at different temperatures (room temperature, 0°C and 80°C).

Concept 3. What is equilibrium state ?

As mentioned earlier, a chemical process can approach a state where no further perceptible change occurs in its macroscopic properties like colour, concentration, pressure, etc. This is easily achieved in a closed system where no transfer of any constituent occurs between the surrounding and reacting system. The tendency to approach this state does not depend on the physical state of the system To give a clear understanding of this state of equilibrium, carry out the following experiments :

Experiment No. 1 : Dissolution of iodine in alcohol-water mixture

You may take about 100 ml mixture of ethyl alcohol and waters mixed in 1:1 ratio by volume in a stoppered vessel. Then add a small crystal of iodine to the mixture and ask your pupils to observe the changes occurring in the colour of the liquid inside the vessel and record their findings. Now ask the following questions .

---

1 What is the colour of the alcohol+water mixture ?
2 What changes in colour do you observe after adding iodine crystal ?

When you find that the iodine crystal has dissolved completely, add relatively larger amount of iodine and again tell the pupils to observe the changes taking place in the solution. Ask a few more questions

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1. What change do you find now in the solution ?
2 Do you observe any variation in colour intensity ?
3 What will you get on leaving this solution for longer time ?
4 Do you think that all of the solid iodine will get dissolved ?

Leave this solution for 15-20 minutes so that no further change takes place in colour intensity. Then ask your pupils why the colour is not changing any more.

Now explain to your pupils that since colour intensity of the solution is not changing any more and there is no further dissolution of solid iodine the system can be said to have reached the state of constant macroscopic properties. This state is called the *state of equilibrium*.

Experiment No. 2 Chemical equilibrium

In order to show that the state of equilibrium is achieved in gaseous systems also, demonstrate the behaviour of NO_2 gas. You can easily prepare this gas by adding copper turnings to 6N HNO_3 solution. The gas can be collected in any glass vessel.

Collect nearly identical amounts of NO_2 gas (reddish brown) at room temperature (25-30°C) in two glass bulbs of identical dimensions. Seal both the bulbs properly so that there is no possibility of leakage. Now immerse one of the bulbs in a bath at 0°C (ice-water) and the other bulb in a water bath maintained at 80°C. Ask your pupils to observe the colour changes taking place. Leave the bulbs for sufficient time in their respective baths so that the gas colour changes no more. Now ask a few questions A Few probable questions are given below :

---

1. What was the colour of the two bulbs before they were placed at two different temperatures ?
2 What change do you notice in colour intensity of the bulb kept at 0°C ?
3 Can you write the reaction responsible for this change ?
4. What change do you notice in colour intensity of the bulb kept at 80°C ?
5. Why do you get this difference in colour intensities of these bulbs kept at different temperature ?
6. Can you explain why the colours of the respective bulbs reach a steady level although they are at different temperatures ?

Now remove the bulbs from their respective baths and keep them at room temperature (Fig. 24 1). Again ask your pupils to record colour changes taking place. When you find that the colour of the gas inside

the bulbs has reached a stationary state, ask youı pupils some questions again.

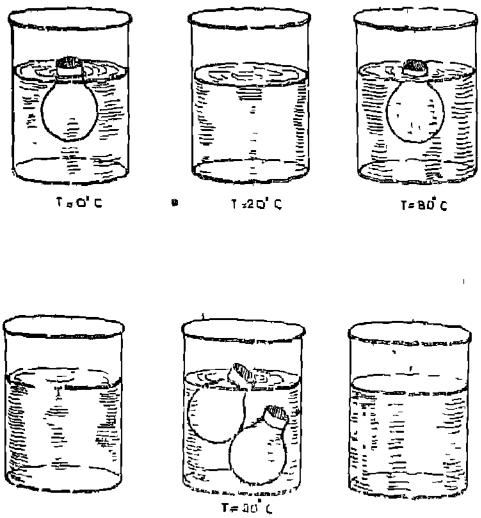

Fig. 24.1 a, b. Two bulbs containing nitrogen dioxide gas: [a] at two different temperatures, i e. 0° and 80° (above); [b] at room temperature, 20°C (below)

What colours do you find now in the two different bulbs ?

Do you notice any difference in bulb-colours from the previous colours (when the bulbs were kept at different temperatures) ?

Can you explain these changes in colour intensities of the two bulbs

---

Based on your observations of the colour changes, explain to your pupils that a chemical system can reach the state of equilibrium, irrespective of the surrounding temperature. In this state of equilibrium, macroscopic properties do not vary with time, i.e. constancy of macroscopic properties is attained. Also point out that the equilibrium state can be reached from either side, i.e. by reaction of the reactant or product molecules. You can take the help of other equilibrium reactions to further strengthen your conclusions. In case the pupils are not clear about the reactions which occur when NO_2 gas is kept at different temperatures, you may explain them.

Physical equilibrium-revisited

You can clarify this concept by demonstrating the process of water vaporization in a manometer attached to a closed vessel, shown below :

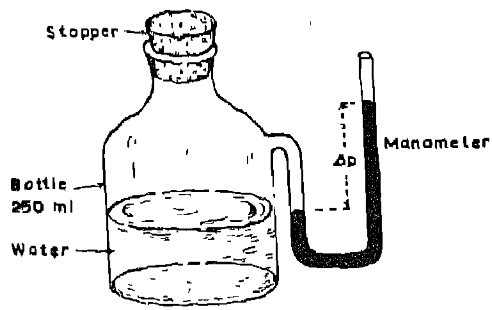

Fig. 24.2 Physical equilibrium $H_2O\ [l] \rightleftharpoons H_2O\ [g]$

Take about 50-60 ml. water in your experimental bottle and then stopper it tightly so that there is no chance for water vapours to escape. Record the liquid level in the graduated arm of the attached manometer. Ask your pupils also to do the same Now start a stop watch and instruct your pupils to record manometer liquid levels after different durations, until the manometer reading comes to a stationary value. Check if they have recorded their observations in a systematic manner in their notebooks. Now ask a few questions.

For what purpose the manometer has been connected to the vaporization chamber ?
Why do you get variation in manometer reading initially, which attained constancy after some time ?
Do you expect any variation in manometer liquid level if the bottle is left unstoppered ?
What will happen to manometer reading if we keep the vaporization bottle in ice-water mixture (having a fixed temperature of 0°C) ?
Do you observe any variation in the level of water taken in the vessel ? (compare the initial level and the level attained when no change occurs in manometers reading).

Record their answers on the blackboard. Then ask them to plot their manometer readings against the corresponding time on a graph paper. Take observations of one of your pupils and you plot these values on a graph-board. This will help the pupils in learning the techniques of transferring experimental data in the form of a graph. You can ask a few questions at this stage also.

1. **What parameters should be plotted on X and Y-axis ?**
2. **Why should you plot time on X-axis.**
3. **What inference can you draw from the shape of the obtained plot ?**

In the light of the experimental findings, you can explain that in the initial stage of rising pressure and evaporation the rate of water molecules was much more than their condensation rate. But with increasing amount of vapours in the chamber, the condensation rate also increased due to which the variation in manometer reading slowed down. Lastly, *when the manometer reading becomes stationary, the number of water molecules entering into gas phase each second becomes equal to the number of molecules entering into liquid phase and a dynamic balance is reached between vaporization and condensation processes*. Molecules move back and forth between the two phases, with condensation and vaporization occuring at equal rate.

In order to convince your pupils further about the equilibrium state, you may take the analogy of honeybees on a beehive. Ask your pupils to imagine the situation after the bees are disturbed. They will find that for sometime the number of bees coming to the beehive is relatively larger than the number of bees leaving the hive. With passage of time, the number of bees coming to the hive decreases. Lastly, a stage is reached when the number of bees coming from and going to the hive becomes almost equal and the number of bees present in the hive changes negligibly thereafter. You can tell your pupils then that an identical situation exists in a chemical system under the state of equilibrium. Under that state the amount of the substance consumed in the forward step is regenerated in the reverse step and, therefore, the aggregate amount remain unaltered.

Test for evaluating pupils' achievement

1. Why are chemical equilibria referred to as dynamic ?
2. Methanol (CH_3OH) can be made according to the following net reaction : $CO(g)+2H_2(g) \rightleftharpoons CH_3OH(g)+\text{heat}$, predict the effect on equilibrium concentrations of an increase in (a) temperature, (b) pressure.
3. What is the influence of a catalyst on equilibrium concentrations of a chemical system ?

4. Consider two separate closed systems, (i) HI and the elements from which it is formed, (ii) H_2S and the elements from which it is formed, each at equilibrium.

   What would happen in each system if the total pressure were increased ? Assume that all reactants and products are gases.

5. When 100g of sugar is added to a vessel containing nearly 100ml of water; which of the following conditions will control the equilibrium between solid sugar and sugar solution ?

   (a) Temperature of the solution

   (b) Stirring of the solution

   (c) Size of the sugar crystals

   (d) Rate of addition of sugar to water.

Method Used

What method of teaching do we adopt in teaching such topics in the schools ? Development of concepts through demonstrations followed by discussion is considered appropriate for such topics. Through question techniques pose problems before the students and, finally, help them in finding out solutions In this chapter, concept of 'reversible reaction', equilibrium state have been developed by demonstration experiments. What other method do you suggest ? Organise group activities to show the effect of various constants on equilibrium of a chemical system.

Transferring experimental data in the form of a graph is considered a skill. Provide data to the students and let them plot a graph. For developing this skill you may use ruled blackboard and coloured chalk.

Prepare a lesson plan for teaching this topic, using various methods which you may consider important.

Assignments

1. Prepare a chart showing different stages before a system reaches equilibrium state.
2. Make a simple assembly which can be used to study the equilibrium vapour pressure.
3. Prepare a simple apparatus which can be used to record the volume of a gaseous product in a reaction chamber.
4. You can teach the dynamic nature of equilibrium using an analogy. Take two wide-mouth test tubes, A and B. Put one glass tube of wider diameter in A and another glass tube of smaller diameter in B.

   Now water is taken in the test tube A The whole arrangement is as shown below.

Now water is transferred from tube A to tube B with the help of the wider tube. Then using the narrow tube water is transferred to tube A and B. Transfer is done alternately and once only in each case. It has been found that after repeated transfers, the liquid in each tube attains a stationary level.

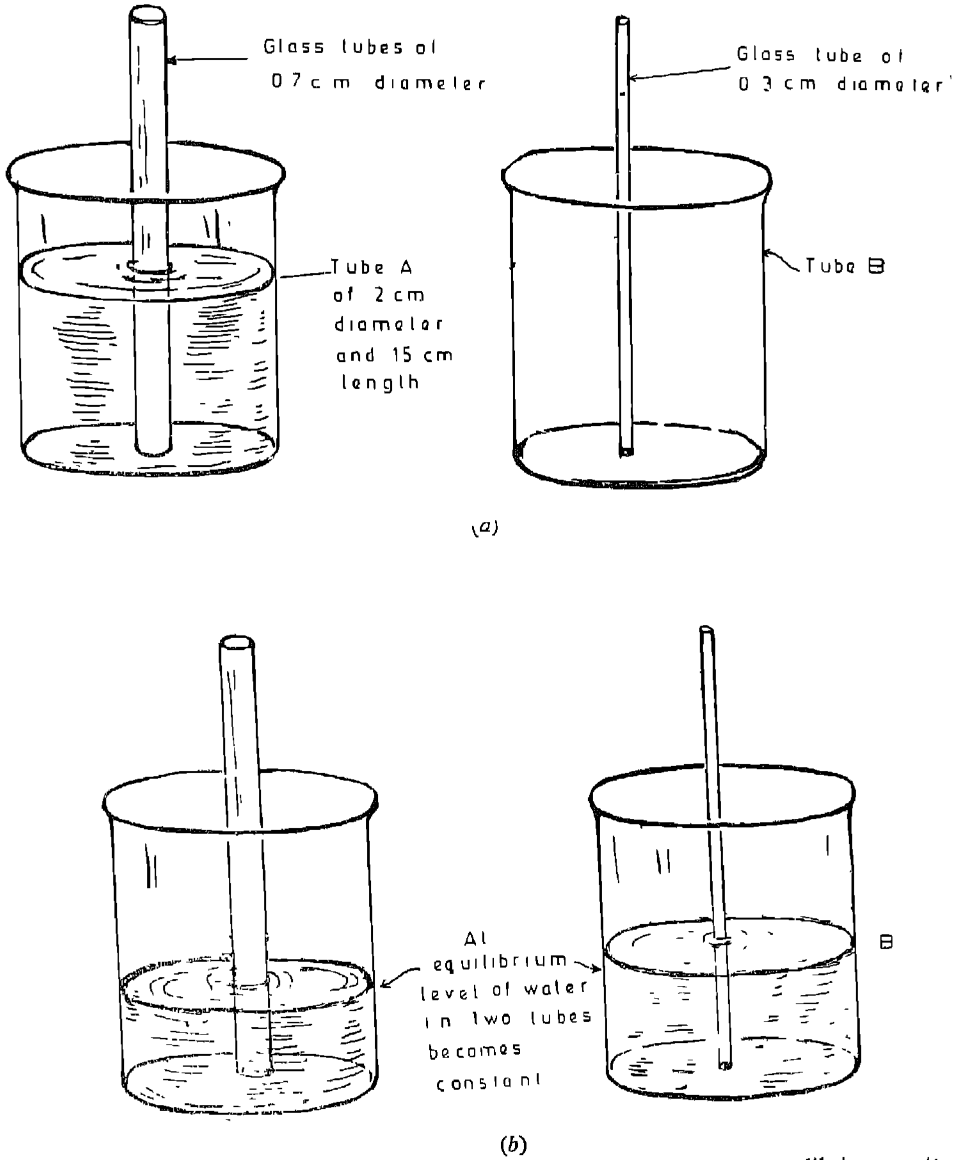

Fig. 24.3. (*a*) Situation before starting the experiment. (*b*) After the equilibrium is attained.

You are expected to comment on the suitability of this analogy. If you find it suitable, fill up the right-hand side of the table below :

	Feature of Chemical reactions	*Feature of the model*
1	Concentration of reagent present initially	is represented by height of the liquid in tube A
2.	Concentration of product present initially	is represented by ....
3.	Concentration of reagent at equilibrium	is represented by..
4	Rate constant for forward reaction	is represented by ....
5.	Rate constant for reverse reaction	is represented by..
6.	Rate of forward reaction initially	is represented by amount of water transferred from A to B in the first transfer
7.	Rate of reaction at equilibrium	is represented by ....

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CHAPTER 25

Chemistry of Some Common Non-metals

Introduction

While studying the Chapter on Periodic Classification, you have learnt about the gradation in physical properties of elements. You know that elements placed in the VA, VIA and VIIA groups of the periodic table possess higher ionization potential, higher electron affinity and acquire electrons in chemical combination from electropositive elements of IA and IIA groups. All such elements fall in the category of Non-Metals. In this Chapter you will find how to teach chemistry of some non-metals like nitrogen, phosphorus, oxygen, sulphur and chlorine and their important compounds. During this teaching how would you help your pupils to learn that there exists a gradation in physical and chemical properties of these non-metals ? Do you think that compounds formed by these non-metals also exhibit gradation in their chemical properties ? How would the pupils believe that compounds formed by these elements serve as an important source for a variety of chemical industries ? While discussing questions like these you may like to emphasize that chemical properties of non-metals and their compounds are the functions of their electronic configuration and structures. It would be quite relevant to take up specific demonstrations and experiments to illustrate the properties of the elements and their compounds under study.

Major Concepts

1. Non-metal elements are electronegative in nature. They combine with hydrogen and form hydrides of great importance (NH_3, H_2O, H_2S, HCl).
2. These elements combine with oxygen and form stable acidic oxides. Oxides form the chief source of producing inorganic acids of industrial importance (HNO_3, H_2SO_4, H_3PO_4, $HClO_4$).
3. Nitrogen and phosphorus are very

essential elements for continuity of life. Soluble salts containing N, S, P, are used as chemical fertilisers in agriculture.

Skills to be developed

—Demonstrate and discuss the non-metallic properties of these elements.

—Demonstrate the methods of preparing important compounds of these elements on a small scale.

—Relate the observed properties of elements and compounds with their electronic configuration and then deduce possible structural formula of compounds.

Development of Ideas/Concepts

You may introduce the chapter by supplying the blank format of the long form of periodic table to pupils or by sketching it on the blackboard and asking the pupils to locate the position of some of the important non-metals.

periodic tables Direct the discussion in such a way that the pupils infer that values of ionization energies, electron affinity and electronegativity (electron attracting property) of elements placed beyond IVA group of periodic table are relativity higher than those placed before it You may like to supply values or display tables of the values in the classroom. Such elements fall in the category of non-metals.

Typical properties of these elements :

1. Except carbon, all non-metals do not conduct electricity.
2. All burn in oxygen and form stable acidic oxides (SO_2, P_2O_5, NO_2).
3. All combine with hydrogen and form hydrides (NH_3, H_2S, HCl).
4. Their atoms have a tendency to cling together and form diatomic (O_2, N_2, Cl_2), triatomic (O_3), and polyatomic molecules (S_8, P_4).
5. All are electronegative elements. (Refer to development of concept.)

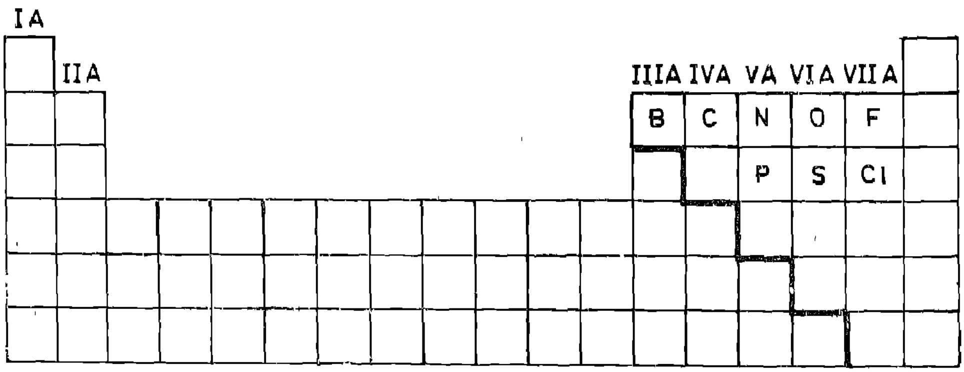


Fig. 25 1. Some non-metals

Activity

Help your pupils to recall some periodic properties of elements belonging to IA & VIIA groups and 2nd or 3rd periods of the

Teachers Activity 1. Behaviour of sulphur on heating.

Take about 15-20g of pure sulphur in a hard glass boiling test tube. Heat the test

tube slowly. Ask the pupils to observe changes in the physical state of sulphur and the corresponding temperatures if possible Help the pupils to infer that from the melting to the boiling stage sulphur exhibits unusual behaviour in various steps shown below.

Pale-yellow solid → Straw coloured runny liquid → A dark viscous liquid (does not flow easily) → More fluid runny again → Boiling at 444°C

Q. 1. How many changes has sulphur undergone on heating ?

Q. 2. Why does sulphur behave like this ?

Q. 3 Does this behaviour have something to do with the structure of molecules/atoms of sulphur ?

Discussion

Help the pupils to visualize three distinct stages on heating sulphur, i.e. solid, runny liquid, viscous liquid and boiling. At which stage molecules/atoms appear to cling to each other ? Suggest atomic clusters of sulphur to explain the observed behaviour. You may like to relate this behaviour with the structure of sulphur as proposed by chemists. Molecular crystals, in which S atoms are bonded to each other by single co-valent bonds, S-S-S angle is 105°. Liquid and stable crystalline form of sulphur at room temperature consist of oct atomic form. Sulphur at its melting point consists of S_8 molecules in the form of rings, which slide over each other in fluid state. As temperature is raised, S_8 rings break in S_8 chain polymer. These chains are entangled with each other, and present resistance to flow (viscous). At still higher temperature and low pressure S_8 chain breaks successively into S_6, S_4 and S_2 chains with least resistance to flow and the liquid becomes fluid again The overall change may be represented as follows.

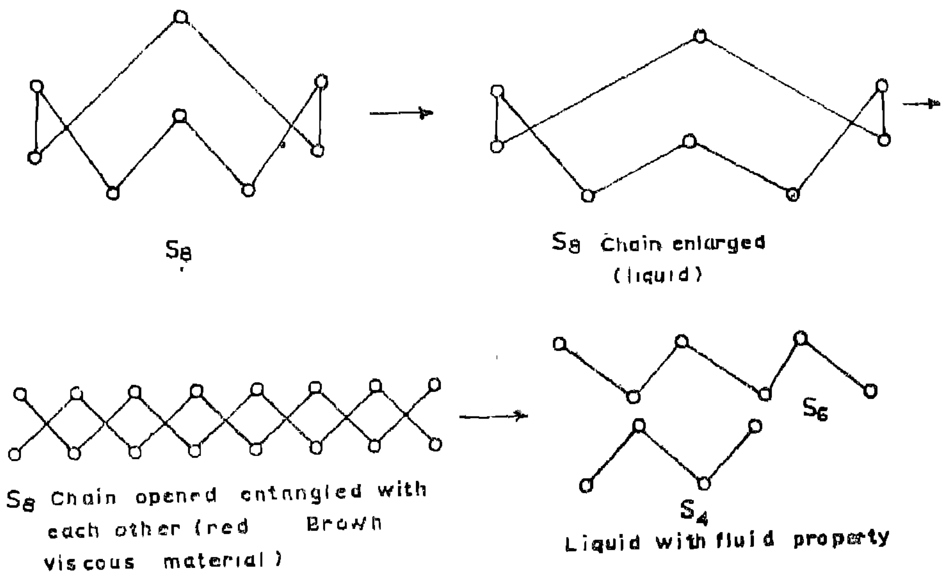


Fig. 25 2. Effect of temperature on sulphur molecule

1. What do we call this property of sulphur ?
2. Suggest another model to explain behaviour of sulphur on heating.
3. Prepare molecular models of S-atoms expected to be present at every stage of heating.

Allotropes of Phosphorus

Help your pupil recall unique behaviour of sulphur on heating and its explanation on the basis of different polymorphic structures of sulphur molecules.

Teachers Activity 2. Relate properties of two allotropes of phosphorus with structures. Study the properties of two allotropes of phosphorus given in the information card.

Which of the allotropic forms of phosphorus is highly reactive ?
Which allotrope is likely to have giant molecular structure ?
Which allotrope is likely to have simple molecular structure ?

Compare the molecular structures of white and red phosphorus molecules and relate their properties. Help the pupils to infer that less energy is required to break-up white phosphorus into smaller units, that is why it is reactive. It must have a simpler structural unit than red phosphorus. X-ray studies have shown that white phosphorus is composed of separate molecules of P_4 tetrahedra which are loosely bound in solid by weak van der Waals forces. Red phosphorus has P-P bond throughout its structure so the whole crystal forms a giant molecule (polymeric form).

1. Draw tetrahedral structure unit of P_4 molecule and giant molecular structure of red phosphorus to show P-P bonds ?
2. Relate other properties with these structures.
3. Discuss why white phosphorus is kept under water and not the red phosphorus.

Comparison of hydrides of nitrogen, phosphorus, oxygen, sulphur and chlorine.

You may take up this activity when study of NH_3, PH_3, H_2O, H_2S and HCl has already been completed. A comparative study may be taken up either in pairs or all hydrides taken together according to convenience.

Activity : Correlating properties with electronic structure of compounds.

Phosphorus Information Card

(You may write the properties on the blackboard also)

Properties	*White Phosphorus*	*Red Phosphorus*
Melting point	40°C	593°C
Boiling point	280°C	Sublimes
Solubility	Soluble in CS_2	Sparingly soluble in CS_2
Toxicity	Highly toxic	Non-toxic
Reaction in Air	Ignites spontaneously at room temperature	Does not ignites below 240°C

Some Properties of Elements P, S, Cl and their Hydrides

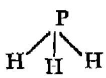
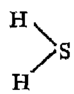
	Phosphorous	*Sulphur*	*Chlorine*	*Nearest Inert gas*
Atomic number	15	16	17	18
Atomic mass	31.0	32.10	35.5	39 9
Molecular Formula	P_4	S_8	Cl_2	Ar
Boiling point	280°C	445°C	—34 5°C	—186°C
Bonding in Hydride	Covalent	Covalent	Covalent	
Formula of Hydride	PH_3	H_2S	HCl	—
Structure Formula			H-Cl	
Ratio of hydrogen atom to non metal	3	2	1	
Chemical nature of hydrides	Basic	Slight acidic	Highly acidic	
Boiling points of hydride	—87°C	—60.2°C	—85°C	
Solubility in water	Slightly Soluble	Soluble	Very Soluble	

Table indicating the properties may either be supplied or developed or written on the blackboard. Other properties may also be tried.

1. Help the pupils to infer that phosphorus, sulphur and chlorine atoms require 3, 2 and 1 electrons respectively to attain the nearest noble gas structure (i e structure of argon atomic number 18). You may like to put up some question like—What is the atomic number of P ? What is atomic number of Ar ?

How many electrons are required by phosphorus in order to acquire electronic configuration of argon gas ?

What is the total electronic configuration of PH_3 gas ?

Why the valency of phosphorous is 3 with respect to hydrogen ?

2. You may hold another type of discussion with pupils. What are the structural molecular formula of hydrides ? Why is hydride of chlorine more soluble in water than that of sulphur and phosphorus ? What is the nature of covalent bond present in hydride of chlorine and in other hydrides ?

Do you think the nature of bond present in hydride is responsible for solubility and other properties of hydrides ?

Through discussion help the pupils conclude that the type of bonds present determines the physical and chemical property of compounds.

3. A further discussion about the size of atoms/ions of hydride may lead them to infer that the size of the ion and inter-attraction between molecules also determine the physical state of compounds

Test for evaluating pupils' achievement

1. Hydrogen belongs to IA group, carbon to IVA group and chlorine belongs to VIIA group of the periodic table.

   The single chemical bond between carbon and chlorine atoms (C-Cl) in a compound would be

A. more polar than bond between hydrogen and chlorine ;

B. less polar than bond between hydrogen and chlorine ;

C. of the same polarity as between hydrogen and chlorine ;

D. of no polarity

2. The single chemical bond between chlorine and chlorine atoms would be

A. Completely ionic

B. Partially ionic

C. Partially polar

D. Completely non-polar.

3. Nitrogen atom in comparison with sulphur atom would be

A. Less electronegative

B. More electronegative

C. Equally electronegative

D. Equally electropositive

4. Electron attracting power of non-metallic element in a molecule is known as :

A. Electron Affinity

B. Electronegativity

C. Electropositivity

D. Electron valency

5. Arrange the elements under study in decreasing order of their electronegativity. Also on the basis of electronegativity values show which hydride of these elements will be the strongest polar molecule.

6. Give reasons for the following

Why non-metals have the tendency to form diatomic and polyatomic molecules ?

Why ammonia and hydrochloric acid gas are highly soluble in water.

Why silver chloride is more soluble in ammonium hydroxide than silver iodide ?

Why fluorine is most active of all halogens ?

7. Read the reaction, $2KI\ (aq) + Cl_2\ (aq) \rightarrow 2KCl\ (aq) + I_2(s)$ give answers of the following questions :—

A. Do you think the above reaction is redox reaction ?

B. Which of the chemical species is oxidized ?

C. Which of the chemical species is reduced ?

D. Which of the chemical species is neither oxidised nor reduced? (Give reasons in every case).

8. Why nitrogen and phosphorus have been considered to be very essential for the living system. (Give at least five reasons).

9. Compare the chemical reactions of sulphuric acid and nitric acid with three metals and two non-metals. Give reasons for difference in behaviour. (Two physical and two chemical).

10. Compare the properties of hydrides of oxygen with the hydrides of nitrogen and sulphur and give reasons for similarities if any

Method Used

What method should we adopt in teaching such topics in the schools ? The present chapter is of descriptive nature where you come across various properties and uses of elements and their compounds. In what way the teaching of this chapter do you find different from the teaching of other chapters studied earlier in this book? In this chapter, it is not possible to show all the properties of the elements and compounds to the students. Show only a few common properties and for the rest prepare a chart. Relate the property with the electronic configuration of the elements. In this regard, a chart showing electronic configuration of

he elements should be used. For having a systematic study of elements and their compounds use *long form* of Periodic Table. For understanding the structural aspects of the compounds, use molecular models made of plastics. Think of some other *teaching aids* for better understanding of structures and related properties of the compounds. Do you think this type of approach will be equally valid for any other *descriptive* chapter of chemistry? Use of *charts*, *tables*, *models* and other teaching aids is considered most desirable in case of such descriptive topics. You will come across another descriptive topic after this. Compare the methods and approaches used in these two chapters

Assignments

1. Prepare a large-size long form of Periodic Table and show the location of all non-metals indicating atomic number, electronic configuration, ionic and covalent radii, ionization energy and oxidation states, melting points, boiling points and electronegativity. Examine gradation of these values and draw generalisation. (*Group-discussion activity*).
2. Make a table of comparison between (a) oxygen and fluorine and (b) fluorine, chlorine, bromine and iodine (prepare instructions for pupil activity).
3. Make molecular models of O_3, S_8 (ring and chain), P_4; red P; HCl, H_2O, H_2S in proportion to hydrogen atom and bonds between them (Ball and stick and space-filling models from plasticine or black soil or plaster of paris.)
4. Prepare a teaching plan for comparison of chemical properties of sulphur dioxide and chlorine (e g. oxidation properties).
5. Prepare three multiple choice items for testing 3 physical characteristics of non-metals and three chemical properties of chlorine, sulphur, and phosphorus.
6. Collect the names and formula of about twenty compounds containing oxygen atoms (oxides, oxy-acids, salts, oxy-chlorides). Calculate the oxidation number (oxidation state) of metals and non-metal atoms present in them.

   What pattern do we get when non-metals are arranged in ascending order of their oxidation number?
7. Devise an exhibition item for display of 'Fountain Experiment' on continuous basis for *hydrogen chloride* and *ammonia gas*.
8. Set up an apparatus to demonstrate the relative diffusion or rate of diffusion of ammonia and hydrogen chloride gas (hydrochloric acid gas).
9. Devise an improvised apparatus for preparing NH_3, H_2S, SO_2 and Cl_2 gas and prepare teaching plans for Class X pupils.
10. Arrange group discussion on some theoretical concepts concerning non-metals, e.g. nature and degree of sharing of electrons between non-metal atoms (covalent and polar-covalent compounds based on electronegativity of the elements. Let some of the pupils come forward to discuss percent ionic character also).

11. Prepare a chart of electronegativity of non-metals.
12. Make attractive flow-charts of all compounds of nitrogen, phosphorus, sulphur and chlorine indicating their different uses. (The flow-chart should reveal the scope of compounds and uses, indicating the importance of a study of non-metals).

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CHAPTER 26

Introduction to Organic Compounds

Introduction

The study of organic compounds is important because they are present in a variety of substances in our daily life, e.g. common fuels, petroleum, cooking gases, firewood; in our foods (cereals, pulses, fruits, vegetables); in drugs and medicines (antiseptics, antibiotics, anaesthetics, vitamins), in clothing (cotton, nylon, wool, silk and polyster fibres), in cleaning agents (soaps, detergents, powders); in cosmetics (snow, vanishing creams, talcum powders) and in most of other substances like rubber, plastics, paper, wax fragrance and polishes, etc. Therefore, the study of organic compounds is essential to understand the various aspects related to life situations and processes occuring in nature and in industries.

How would you introduce the idea of organic compounds to your pupils most effectively? How can you help them to see and infer that properties of these compounds are related to their structures? In this chapter, you may find useful suggestions for such ideas.

Major Concepts

(*i*) Organic compounds are compounds of carbon.

(*ii*) Large number of organic compounds are due to catenation property of carbon atoms.

(*iii*) Hydrocarbons are parent organic compounds.

(*iv*) Organic compounds can be classified on the basis of functional groups.

(*v*) A class of organic compounds in which each member differs from its preceding or succeeding member by a—CH_2 group, is known as homologous series Members of the series exhibit gradation in physical properties (e.g. viscosity, boiling points, melting point, etc.) and similarity in chemical properties,

(vi) Molecules with the same number of atoms having different arrangements are called isomers

(vii) The organic compounds are named based on IUPAC systems of nomenclature.

Major Objectives

1. To *differentiate* between molecular, structural and *condensed structural farmulae* of organic compounds
2. To *understand* the reasons for the existence of a large number of organic compounds.
3. To study the *relations* between properties and structures of the organic compounds.

Skills

1. Skill of classifying given objects made up of organic materials into different groups of substances.
2. Skill of writing correct names and formulae of compounds according to IUPAC system.
3. Skill of predicting the properties of organic compounds on the basis of a functional group.

Development of ideas/concepts through activities

Activity 1 : Classifying organic materials.

1. Collect a few materials from the laboratory or the market comprising materials like plastic-scales, bottles, polythene bags, nylon-buttons, different varieties of seeds, fruits and vegetables, rubber, nylon, cotton and other kinds of cloth pieces; ball pens, paper, leaves, small pieces of wooden materials, etc. Mix them and display on a table.
2. You may roughly divide the mixed things into 4-5 sections and call them section A, B, C, D, E. Ask your pupils (divided into small groups) to arrange the material under every section and further into groups if necessary on the basis of as many criteria (like colour, brittleness, shape, uses) as they could think (10-15 minutes). Let your pupils handle them freely.
3. Discuss with the whole class the grouping of materials done by the pupils' groups.

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1. How many groups of materials you have made from section : A, B, C, D, E ?
2. On what basis the groupings have been done ?
3. Can you think of the criteria for grouping materials which is not thought out by others ?

Think about new similar materials not supplied to you but you might have seen in your home, market, industry, etc (5 minutes).

4. Through discussion, impress upon the pupils that materials supplied to them may be classified into various groups, *e.g. man-made* substances and natural substances, which may further be classified into fuels, foods, clothing material, plastic, rubber and others.

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1 What is the] common substance in all such materials ?

Activity 2

1. Pupils may be asked to collect small square (5 cm × 5 cm) pieces of varieties of clothing material, paste

on different pages of their notebooks and label them nylon, rayon, cotton, wool, silk, etc.)

2. Pupils may be encouraged to look into resource and write the names of the compounds of which materials listed above are made of.
3. Similar activity may be repeated with various plastics, rubbers and cosmetic materials.

Activity 3. Common material of all organic substances.

1. Take small pieces of four different organic materials you have studied in activity 1. Put such pieces into four different dry and hard glass test tubes A, B, C and D. Add a pinch of copper oxide to each of them. Heat them thoroughly (it is advisable to use the delivery tube with a bulb as shown in Fig. 26.1). Lower end of the delivery tube may be dipped into another test tube containing lime water.

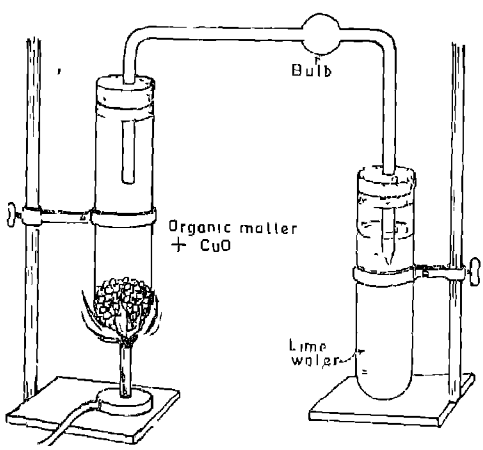


Fig. 26.1. Showing that all the organic substances contain common matter (a schematic diagram of one set)

1. What do you observe on heating ?
2. Do you observe the change in colour of lime water ?
3. Do you observe some water drops in the bulb of the delivery tube on cooling ?
4. Do you observe the same phenomenon in all the four cases ?
5. What do you infer from these observations ?

Help the pupils to generalize that different organic substances contain carbon and hydrogen. Carbon is converted into CO_2 and hydrogen into H_2O in the above experiment. At this stage, it should be emphasised that there are also organic compounds which possess oxygen, nitrogen, halogens and sulphur in addition to carbon and hydrogen. Would you like to test for chlorine, bromine, iodine, sulphur and phosphorus in organic compounds in the laboratory ?

The organic substances which consist of carbon and hydrogen only are called 'hydrocarbons', e.g. methane, ethane Set up an experiment as shown in Fig. 26.2.

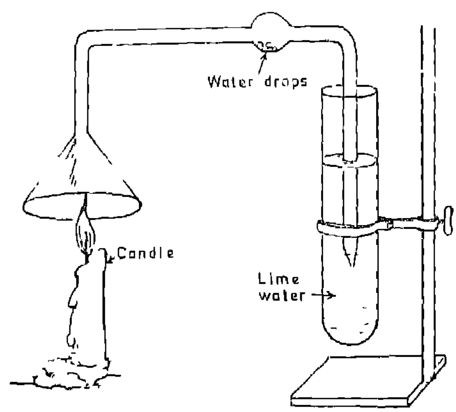


Fig. 26.2. Burning of candle

(*i*) What do you observe in the above experiment ?

(*ii*) Which of the element do you expect are present in the wax ?

(*iii*) Do you agree with the statement 'wax falls in the category of hydrocarbon' ?

2 *Organic compounds* consist of two parts (*i*) alkyl or aryl group and (*ii*) functional group.

Activity 4 :

You may use information card No. 1 and write the information on the blackboard regarding hydrocarbons.

1. What is the relation between molecular formula of a hydrocarbon, alkyl group and hydrogen in a hydrocarbon molecule ?

Information Card No. 1

Name of hydrocarbon	*Molecular formula*	*Name of the atom-removed*	*Alkyl* group*	
Methane	CH_4	H	CH_3	—methyl
Ethane	C_2H_6	H	CH_3CH_2	—ethyl
Propane	C_3H_8	H	$CH_3CH_2CH_2$	—propyl
Butane	C_4H_{10}	H	$CH_3CH_2CH_2CH_2$	—butyl

* The group obtained after removing a hydrogen atom from a saturated hydrocarbon is called an alkyl group

Information Card No. 2

Name of compound	*Molecular formula*	*Atom removed*	*Alkyl*	*Name of the alkyl group*
Methyl chloride	CH_3Cl	Cl	CH_3	—methyl
Ethyl chloride	CH_3CH_2Cl	Cl	CH_3CH_2	—ethyl
Propyl chloride	$CH_3CH_2CH_2Cl$	Cl	$CH_3CH_2CH_2$	—propyl
Butyl chloride	$CH_3CH_2CH_2CH_2Cl$	Cl	$CH_3CH_2CH_2CH_2$	—butyl

1. Which atom is removed in order to get alkyl group from the organic compound ?

2. Which of the alkylg roups are common in both the information cards No. 2 and 3 ?

3 What would you call chlorine and hydrogen atoms in a molecule of hydrocarbons ?

Hydrogen and chlorine atoms in hydrocarbons are known as substituent groups. They do not possess the characteristic properties of ions.

Now you provide Card No. 3 to your pupils and ask them to fill the name of alkyl and substituent groups.

Information Card No. 3

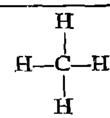
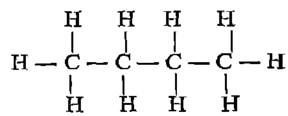
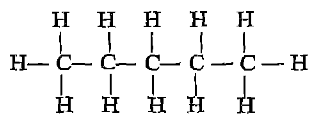
Compound	*Name of the alkyl group*	*Name of substituent group in compound*
$CH_3CH_2CH_3$	?	?
CH_3-CH_3	?	?
CH_3CH_2-Cl	?	?
$CH_3CH_2CH_2CH_2Cl$	?	?

Activity 5 : Molecular complexity using —ball and stick models.

Look at the molecular and structural formulae of some the hydrocarbons in the information card No. 4.

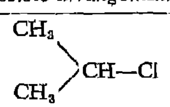
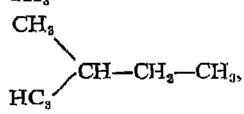
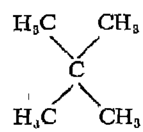
1. What is valence of each carbon atom in all compounds ?
2. Is it possible to rearrange the carbon and hydrogen atoms in a chain without disturbing valence of carbon atoms ?
3. In how many ways the number of carbon atoms in molecule of pentane be arranged ?

Information Card No. 4

Compound	*Molecular formula*	*Structural formula*
Methane	CH_4	
Butane	C_4H_{10}	
Pentane	C_5H_{12}	

Look at the various arrangements of the compounds C_3H_7Cl and C_5H_{12} provided in information Card No. 5.

Information Card No. 5

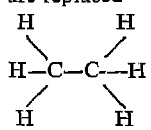
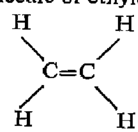
Compound	*Various possible arrangements*
C_3H_7Cl	CH_3—CH_2CH_2—Cl, 
C_5H_{12}	$CH_3CH_2CH_2CH_2CH_3$,  

1. **Do you think that number of C and H atoms are lost in rearrangement ?**
2. **Do you notice any change in number of CH_3 or CH_2 groups in molecular rearrangement ?**
3. **What are these rearrangements of molecule called ?**

You may demonstrate this with the help of ball-and-stick structural models to the pupils and deduce the definition of *isomerism*.

Look at the properties of ethane and ethylene

Information Card No. 6

Properties	*Ethane, C_2H_6*	*Ethylene, C_2H_4*
Oxidation	Oxidises to (CO_2+H_2O)	Oxidizes to (CO_2+H_2O)
Addition of H_2 molecule	No reaction	One molecule of H_2 is added for each molecule of ethylene
Reaction with Cl_2 molecule	Successively hydrogen atoms are replaced	One molecule of Cl_2 is added for each molecule of ethylene
Structural formula		

bonding between C-C atoms in the two compounds is different. (How ?) In one case carbon atoms are bonded by single bond while in other by double bond Similarly the properties of the compounds listed in information Card No. 2 are governed by presence of chlorine atom in them. Thus, it can be inferred that the properties of the organic compounds are governed by the presence of certain atoms or bonds (double bond in the above case) Chemists call such atoms or bonds as *functional groups*. Characteristic reactions of organic compounds are due to the presence of such functional groups. Similar to Cl (as shown in Card No. 2) one can replace hydrogen of a hydrocarbon by other atoms or group of atoms giving rise to various classses of compounds. For example, if in C_2H_6, we replace one H by—OH group, we get C_2H_5OH, you will come across a few more illustrative examples in Information Card No. 7.

1. **What are the common properties of the two compounds ?**
2. **What are the dissimilar properties of the compounds ?**
3. **What is the common of two structural formulae ?**
4. **In what respect structural formulae of the two compounds differ ?**
5. **What factors seem to be responsible for difference in properties ?**

Help the pupils to infer that in both the compounds hydrogen-atoms are bonded to carbon atoms in a *similar manner*. However,

1. What is the functional group present in ethane ?
2. What is functional group present in ethylene ?

Organic compounds can be classified on the basis of functional groups present in them.

Activity 6 · Functional groups in organic compounds.

1. What are the functional groups present in the following compounds ?
2. $CH_3CH_2CH_3$, $CH_3CH_2CH_2OH$, $C_6H_5NH_2$, CH_3COOH and $C_6H_5CONH_2$ (Hint—Match with similar compounds given in Card No. 7)

Method Used

What method should we adopt in teaching such topics in the schools ? Similar to the previous one, this chapter also fall in the category of descriptive chapters. Use of charts, models and other teaching aids will be desirable As you did regarding classification of elements (in the chapter of periodic properties of elements), ask your students to classify the organic compounds based on their physical and chemical properties In what way do you consider this classification different ? To understand the geometry of the organic compounds use of molecular models will be very vital. Since properties of organic compounds are very much linked with the structure, it would be desirable to expose the students to the structure of such compounds. What are the various ways for improvising molecular models ? Do you think students will be benefited by improvising such models in group-work ?

The special method adopted in this chapter is to provide information/data to the students on cards and after discussing the imformation provided in the card ask

Look at the each compounds in Information Card No. 7

Information Card No. 7

Compound	*Formula*	*Structure of functional group*	*Name of the functional group*
Ethane	CH_3-CH_3	—	Nil
Ethylene	$H_2C=CH_2$	$C=C$	Double bond
Acetylene	$HC\equiv CH$	$C\equiv C$	Triple bond
Ethanol	H_3C-CH_2-OH	$-OH$	Alcoholic group
Acetaldehyde	$H_3C-O(=O)-H$	$-C(=O)-H$	Aldehyde group
Propanone	$H_3C-C(=O)-CH_3$	$>C=O$	Ketone group
Acetic Acid	$H_3C-\overset{O}{\overset{\|}{C}}-OH$	$-\overset{O}{\overset{\|}{C}}-OH$	Carboxylic group
Ethylamine	$CH_3-CH_2-NH_2$	$-NH_2$	Amino group
Acetamide	$CH_3-\overset{O}{\overset{\|}{C}}-NH_2$	$-\overset{O}{\overset{\|}{C}}-NH_2$	Amide Group

them to make conclusions. In what way do you find this method different from the rest of the method you have tried earlier?

Arrange group-work and field trip for visiting some chemical industry.

Assignments

1. Make a collection of plastics and man-made fibres to illustrate the properties of such substances
2. Make a model of the tetrahedral carbon atom.
3. Make a set of models to illustrate isomerism.
4. Plan a teaching sequence: what should go to Lesson 1, what in Lesson 2, etc.
5. Devise tests to ascertain whether pupils really understand isomerism.
6. Devise a way of teaching the meaning of the words, monomer, dimer and polymer.
7. Try out the distillation of crude oil and collect the fractions. Show the complete set-up to the pupils.
8. Try out the destructive distillation of coal or wood to illustrate how different organic substances can be obtained from them.
9. Make a chart of common fuels, indicating from where they are obtained
10. On what basis you may say that all the four bonds in methane molecule are equivalent. (Discussion).

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CHAPTER 27

Measurement

Introduction

Measurement is essential in everyday life and in the fields of science and technology to give us quantitative relationships among different physical quantities. Measurement of any physical quantity requires a standard, called a 'unit', for comparison, and can be expressed in terms of a number accompanied by a unit. There are seven basic or fundamental units in the SI (International System of Units) Other units, called 'derived units' can be expressed in terms of these fundamental units. Some physical quantities can be measured directly using appropriate devices and others can be measured or estimated indirectly. Various instruments and techniques can extend our ability to measure a wide range of physical quantities having extremely large and extremely small magnitudes. For example, the range of distances may vary from atomic (10^{-15}m) to astronomical and integralactic (10^{26}m) distances. In this chapter, you will learn about the use of self-study method in teaching the measurement of very very large and very very small distances You will also learn how to plan pupil activities and demonstration experiments and prepare instructional material for self-study method.

Major Concepts

In teaching measurement of distances, the following concepts are to be developed:

(*i*) The measured value of a physical quantity is expressed in terms of a number and the unit of the quantity.

(*ii*) In the SI, there are seven basic and two dimensionless supplementary units.

(*iii*) The units for all other physical quantities may be derived from the basic (fundamental) units.

(*iv*) Large distances can be measured by the triangulation method.

(*v*) Small distances, too small to be directly measured, can be estimated indirectly.

SI Units

You will study the salient features and use of SI Units by the self-study method In the *self study method* you study the material on your own, ordinarily without any help from your teacher. The material can be readily comprehended and to ensure this you may answer the questions as you come across them while reading the material. You can answer these questions only if you understand the material. If you could not answer a question do not study further, try to re-study the material before you look for help. The answers to the questions are given for your convenience. You may wish to prepare and use similar material in the class you teach. Although evaluation is built into the material, separate test may be given to further ensure that the pupils have understood the material The tests could be graded by the better students of the same class using a key supplied by the teacher.

Illustration

The "System International d' Unit' s" (The International System of Units) abbreviated as SI Units was formally recommended by the General Conference on Weights and Measures in 1960. The Government of India has already accepted the system in principle. Most of the other countries of the world have already adopted the SI-Units.

The SI Units are easiest for remembering and practical work. The salient features of the SI Units are as follows :

1. Rational . It absorbs the rationalised MKS system
2. Coherent . It is based on a certain set of 'basic units' from which all 'derived units' are obtained by multiplication or division without introducing numerical factors. In addition there are 'dimensionless units' for plane angle and solid angle.
3. Comprehensive · It uses only seven base units and two dimensionless units to cover all the fields of science and engineering.

Definitions of the base and dimensionless units

kilogram (kg)	The kilogram is the unit of mass equal to the mass of the international prototype of the cylinder at Sevres.
metre (m)	The metre is the length equal to 1 650 763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels $2p_{10}$ and $5d_5$ of the krypton-86 atom
second (s)	The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom.
kelvin (K)	The kelvin unit of thermodynamic temperature is the fraction 1/273 16 of the thermodynamic temperature of the triple point of water.

ampere (A) — The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre length

candela (cd) — The candela is the luminous intensity, in the perpendicular direction, of a surface of 1/600 000 square metre of a black body at the temperature of freezing platinum under a pressure of 101 325 newton per square metre

mole (mol) — The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0 012 kilogram of carbon 12

radian (rad) — The radian is the plane angle between two radii of a circle which cut off on the circumference an arc equal in length to the radius

steradian (sr) — The steradian is the solid angle which, having its vertex at the centre of a sphere, cuts off an area of the surface of the sphere equal to that of a square having sides of length equal to the radius of the sphere

Derived Units

The derived units can be obtained by using the coherent feature For example, the velocity is defined as displacement per unit time or

$$|\text{velocity}| = \frac{|\text{displacement}|}{|\text{time}|} = LT^{-1}$$

Thus, in SI units, $|\text{velocity}|$ S.I. = m/s

Units for other physical quantities are given in Table 1 below Please fill in the blanks.

Table 1

SI Units for Common Physical Quantities

Physical Quantity	*Definition*	*Dimension*	*Unit*	*Unit Symbol*
velocity	$\frac{\text{displacement}}{\text{time}}$	LT^{-1}	metre/second	m/s
acceleration	$\frac{\text{change in velocity}}{\text{time}}$	—	—	—
density	mass/volume	ML^{-3}	kilogram/meter^3	kg/m^3
force	mass × acceleration	—	or newton	N (—)
work/energy/heat	force × displacement	—	or joule	J (—)
power	work done/time	—	or watt	W (—)
charge	ampere × time	IT	Coulomb	C (=AS)
potential	work/charge	$LM^2 T^{-3} I^{-1}$	volt	V (=J/C)
resistance	potential/current	$ML^2T^{-3}I^{-2}$	ohm	Ω(=V/A)
specific resistance	$\frac{\text{resistance} \times \text{area}}{\text{length}}$	—	—	—

(*Contd.*)

velocity	$\frac{\text{displacement}}{\text{time}}$	LT^{-1}	meter/second	m/s
acceleration	$\frac{\text{change in velocity}}{\text{time}}$	LT^{-2}	$\frac{\text{meter}}{\text{second}^2}$	m/s^2
density	mass/volume	ML^{-3}	kilogram/meter^3	kg/m^3
force	mass × acceleration	MLT^{-2}	kilogram, meter/second^2 or newton	N(=Kg m/s^2)
work/energy/heat	force × displacement	ML^2T^{-2}	$\frac{\text{kilogram meter}^2}{\text{second}}$ or joule	J(Kg m^2/s^2)
power	work done/time	ML^2T^{-3}	$\frac{\text{kilogram meter}^2}{\text{second}^3}$ Or watt	W(kg m^2 s^{-3})
charge	ampere × time	IT	coulomb	C (=AS)
potential	work/charge	$ML^2T^{-3}I^{-1}$	volt	V(=J/C)
resistance	potential/current	$ML^2T^{-3}I^{-2}$	ohm	Ω(=V/A)
specific resistance	$\frac{\text{resistance area}}{\text{length}}$	$ML^3T^{-3}I^{-2}$	ohm meter	Ω-m

Measurement of Large Distances

You will learn about pupils activity method in the measurement of large distances. In this method, you plan and provide some activities to the pupils through which they can learn the underlying principles. While the pupil is performing the activity, you may put to him suitable questions to find out 'how' and 'why' he is doing certain activities and 'what' inferences he draws from the observations. This exercise may help the pupil in obtaining a generalisation. The measurement of large distances, illustrates the *principle of triangulation method* which can be taken as pupil's activity

Triangulation Method

You have to measure the distance of a very distant, tall electric pole at point O from a point A in the college ground. Fix a survey stake at A. Fix another survey stake at point P in the college ground so that both the stakes at A and P and the electric pole are in the same line. Join P to A and draw a straight line PA. Then draw a straight line AB at a convenient distance perpendicular to AP and fix a stake at B The line AB is called the '*base line*'.

On the other side opposite to the pole, look at point D in the same line as B and the electric pole and fix a stake at D. Draw a straight line DC perpendicular to base line AB produced to met it at C. Fix a stake at C Measure the distances AB, BC and CD using a metre scale. You have thus generated two similar triangles OAB and BCD as shown in Fig. 27.1. Using the geometrical properties of similar triangles, determine the distance AO.

Construction of a Parallax Viewer

To understand 'parallax', look at a vertical pencil kept in hand against a fixed background (wall) with one eye at a time Move your eye horizontally towards left or right. What do you observe ? You will notice the apparent shift of the pencil with respect to its background. This shift is called 'parallax' and this property is utilized in 'parallax viewer'.

Look at the diagram of parallax viewer as given in Fig. 27.2 and construct one. Use the parallax viewer to find the distance from college ground to an electric pole (in metres).

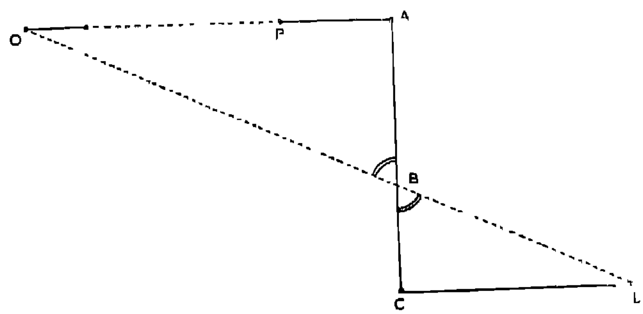

Fig. 27.1. Principle of triangulation method

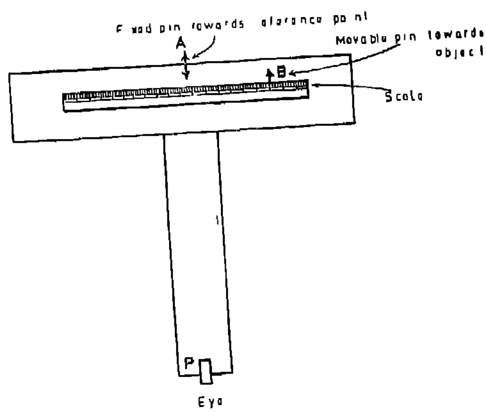

Fig. 27.2. Parallax viewer

Possibly there will be a difference between the values obtained by this method and by triangulation method Errors in measurement can come from human error, but in any event, measuring instruments can only be of limited accuracy Therefore, all measurements are subject to some element of uncertainty.

Measurement of Small Distances

You may perform an experiment to estimate the order of molecular size. Take a shallow tray preferably not less than 60×60 cm^2 in size with water to a depth of about 1 cm. Sprinkle talcum powder over the surface evenly Put one drop of turpentine oil using an eye dropper at the centre of the water surface.

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1 **What do you observe on the surface of water ?**
2. **How can you determine the thickness of oil film ?**
3. **How can you find the volume of one drop of turpentine oil ?**

Method Used

In this chapter, the self-study method and pupil activity method have been used for developing the concepts in measurement of distances. Think over the characteristics of these two methods and where and how you can use them.

Assignments

(*i*) Prepare self-study material on MKS units and dimensions.

(*ii*) Prepare a simple device for measurement of time.

(*iii*) The ordinary weight box has weights, one piece of 1g., two pieces of 2g. and one piece of 5g., which in suitable combination can be used for obtaining any integral weight from 1 to 10g. Can you think of any other set of four weights for the same purpose ?

(*iv*) Improvise a pan balance. (You can use coins in place of standard weights)

(*v*) What experiences can you give pupils to get a feel of the units of length, area and volume ?

(*vi*) Construct a simple tool for measuring temperature.

(*vii*) Estimate the weight of air in a room :

(*a*) You can prepare a card-board box of capacity 22.4 litres. The air inside weighs 29g. approximately.

(*b*) In addition you may prepare a milli-mole box out of paper.

(*viii*) Study changes in surface area when a cube is cut into eight small cubes. If the linear dimensions of a cube are doubled what happens to its surface area and volume ? (The difference in rates of increase of volume and area places a limit on the size of cells in biological systems as nutrient materials have to diffuse through the surface.)

(*ix*) If the oil layer in section on Measurement of Small Distances is considered to be one molecule thick and molecules are assumed to be essentially cubes, how many molecules would fill one millilitre ?

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CHAPTER 28

Description of Motion

Introduction

In this age of fast moving world, it is essential for every one of us to know the basic laws and concepts of motion. You are aware of the alarming growth in the rate of persons being killed by road, rail/air accidents. We may not be able to eliminate accidents but we can certainly reduce their chances by teaching principles of machines to our citizens. This unit is aimed at bringing about an awareness of simple concepts related to motion.

Major Concepts

The major concepts regarding motion are as follows :

1. A quantity that has a magnitude and a direction is called a vector.
2. A quantity that has a magnitude only is called a scalar.
3. A vector can be represented by an arrow, the length of the arrow being proportional to the magnitude of the vector and the arrow head indicating the direction
4. If a vector is displaced parallel to itself it remains unchanged.
5. On reversing the direction of the arrow head the vector gets its sign reversed.
6. The resultant of a set of vectors is that single vector which can replace the original vectors taken together.
7. If two or more vectors are joined tail to tip successively their resultant is given by an arrow from tail of the first to the tip of the last vector.
8. Slope of the distance-time graph gives the magnitude of the velocity (speed).
9. Slope of the speed-time graph gives the magnitude of the acceleration.
10. A vector can be resolved into two components having a given angle between them.

First of all, you should initiate activities to help your students understand that

physical quantities can be divided into scalars and vectors. One way of doing this is as follows .

Ask a student to walk 4 feet towards direction of the north and then three feet towards the direction of east

1. How much distance has been covered by the student ?
2. What is the shortest distance between the initial and final positions of the student ?

The above can be depicted on the board using a scale drawing. The students may also make scale drawings in their notebooks.

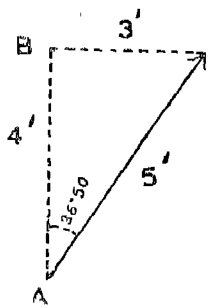

Fig. 28 1 Vector sum of two displacements

Using this diagram students should be made to realize that actual distance travelled from A to B and then from B to C is not the same as the actual distance from A to C. It should be emphasised that by saying that the student has travelled a total of 7 feet would carry no meaning because that will not specify his final position. His final position would be known if we say that he is 5 feet away making an angle 36°50′ east of north. If we specify direction alongwith the distance it becomes a vector quantity called displacement.

To reinforce the concept let a student walk along the circumference of a circle having a radius of 3 feet and let him complete one round.

What is the distance travelled by the student ?

What is the displacement of the student from the initial position ?

At this stage, it may be made clear that vectors cannot be added or subtracted like scalars. This can be easily done by using some familiar examples like displacement (vector) and mass (scalar) and using diagrams on the board. For example, the following diagrams may help you to develop some of the concepts listed earlier in this unit.

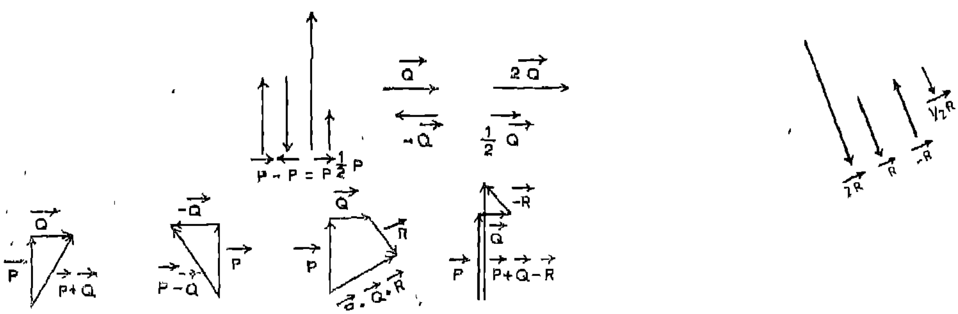

Fig. 28.2 Vector addition and subtraction

For the resolution of a vector into two components a similar method may be used

For developing the concepts about motion (displacement, velocity, etc.) graphical approach may again be used. You can give your students specific problems and ask them to solve them using scale drawings or graph papers. You should supervise the work of individual students and help them, if necessary Later on you can solve a similar problem on the board with the help of your students.

All the quantities having magnitude and direction are not necessarily vectors unless they fulfil the commutative property viz., $\vec{A} + \vec{B} = \vec{B} + \vec{A}$. For example, moment of inertia is not a vector. For further description, please see *Physics* by Halliday and Resnick.

Questions for Review

1. Under what conditions is the actual distance travelled by a body numerically equal to the magnitude of its displacement?

2. A motor boat moves straight across a river 300 m wide, at a speed of 10 km/hr. The water flows at 5 km/hr. How far down the river the motor boat will land? What time is taken by the boat in crossing the river?

3. A pilot cruising at a speed of 600 km/hr heads his plane due east. He finds a 60 km/hr wind blowing from the south. Find the ground speed of the plane and the direction in which it flies.

4. Classify the following into vectors and scalars. Speed, mass, temperature, displacement, velocity, force, work, volume, energy and acceleration.

5. The figure below represents the speed of a cyclist during 30 seconds:

What was the distance covered by the cyclist in first 15 seconds? How far did

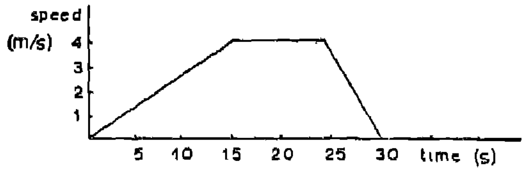

Fig 28 3 Speed time relationship

he go in 30 seconds? What was the average speed during the trip? What was the magnitude of acceleration during the first 15 seconds?

Method Used

What method will you use in teaching this unit to your pupils? Firstly it is suggested that you give the pupils some activity to clarify the concepts. Secondly graphical representation of the quantities and their relationships is recommended. Good blackboard work using coloured chalk to indicate different quantities may be used. A graphboard is to be preferred, but if this is not available, lines may be drawn on the blackboard using a metre scale to prepare a graph board. You may practise blackboard work by and drawing diagrams and geometrical figures on board. Alternatively, you may use diagrams prepared on a large drawing paper fixed on a cardboard.

You may also have to use discussion method to clarify the concepts. You may begin with pupils' known concepts, and slowly giving new experiences, making observations, establishing relationships, and applying known laws and principles, develop the new concepts and generalisations.

Further, you may also give numerical exercises to establish the quantitative relationships.

For what kind of subject-matter should such methods be used ?

Assignments

1. Take a rectangular wooden plate approximately $30 \times 30 \times 1$ cm^3 and draw horizontal and vertical lines on it keeping a distance of 3 cm between any two consecutive horizontal or vertical lines At each junction fix a nail about 2 cm in height. Have elastic strings or bands with loops at each end to represent vectors of different magnitude Use this as a teaching aid to show addition and subtraction of vectors. You can use paper-cones (of different colours) to indicate the direction of vectors.

2. Have some of your students walk or run 100 m and measure their average speeds. Ask the students to depict their velocities using vector diagrams and see if they make any mistakes.

3. Describe a method to determine the acceleration of your hand while walking. Can you use the same method to determine retardation also ?

(**Hint :** You can use a paper tape and a ticker-timer.)

4. Prepare a chart showing or comparing different speeds known to you, e.g. speed of an ant, walking/running speed of a man, speed of a train/automobile/aeroplane/steamer/rocket/and light, etc.

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CHAPTER 29

Laws of Motion

Introduction

Classical Mechanics is one of the most important areas of Physics. Developed by Galileo and Newton in the 17th century, classical mechanics remained the only theory of mechanics for over 2000 years (until the theory of relativity modified it) and it correlated quite accurately all observations for the motion of macroscopic objects. We now know that classical mechanics does not apply to very small atomic-sized systems or to objects whose velocity approaches the velocity of light. But that does not diminish the value of classical mechanics, for it is an important fact that all theories have been found to have limited range of application. The grand theory that correlates all physical observations is yet to be found

Famous for absent-mindedness Newton was a genius whose modesty is reflected in his deathbed remarks. "If I have seen farther than others, it is by standing on the shoulders of giants". Newton remained a bachelor but he was wedded to science and mathematics which were his sole concern. His 'Principia' is one of the greatest monuments of the human intellect. In it Newton lay the foundations of mechanics, broad enough to explain all future developments.

Alexander Pope has rightly described "Nature and Nature laws lay hid in night, God said, 'Let Newton be !' and all was light".

Major Concepts

1. A body remains at rest (or in motion with uniform velocity) unless it is acted upon by an unbalanced external force.

2. Mass of a body is a measure of its inertia.

3. A body under the influence of an unbalanced force moves with an acceleration.

4. The acceleration of a body under the influence of an unbalanced force is directly proportional to the magnitude of the force when the mass of the moving system is unchanged.

5. The acceleration of a body under the influence of an unbalanced force is inversely proportional to the mass of the body

if the force remains constant

6 The direction of the acceleration of the body is the same as that of the unbalanced force acting on it

7 To every action there is an equal and opposite reaction.

8. The forces of action and reaction act on two different bodies.

This unit can be best introduced by involving your students in interesting activities. You can hang a banana using a long string and ask your students to try to cut it keeping a knife initially in contact with it in a horizontal direction. Obviously as the knife moves the banana also moves in the same direction. The student finds it difficult to cut the banana. Now ask him to repeat the activity using the knife in any manner. If the student cuts the banana you can discuss the reason If the student still fails, you can cut the banana yourself by bringing the knife near the banana using a swift jerk. The discussion should lead to the development of the concept of inertia. To reinforce the concept you can ask the students to do the famous coincard-tumbler experiment.

Alternatively you can place a stack of coins on a piece of paper near the edge of a table and ask one of the students to pull out the paper without disturbing the stack of coins If he fails you can demonstrate the same. The trick is to be discussed to develop the concept of inertia.

The following activities may also be tried. The reasons for particular observations may be discussed.

1. A 200 gramme weight is suspended from a stand using a long string such that about ten centimetres of the string hangs below the weight. The lower end of the string is (i) pulled gently, (ii) pulled using a jerk.

2. With the help of a book a ball is kept moving on a table, then the book is suddenly withdrawn.

Ask your students to try to pull/push things of different weights and let them have a feel of inertia.

You should put thought-provoking questions during the demonstrations or student-activities so that students arrive at certain conclusions that lead to the development of the concept of 'inertia'

You may also ask the students to give you examples from their own experiences to show the application of the law of inertia in daily life.

To demonstrate the relationship between the acceleration produced and the unbalanced force acting on a body PSSC experiment may be done. In this experiment a cart is pulled using a rubber band stretched to a constant length (measured along a ruler fixed to the cart). The speed of the cart is measured using a ticker tape It will be seen that the speed of the cart goes on increasing although the force is the same. Using the speed versus time-graph the acceleration can be determined The experiment may be repeated using different forces exerted by the band stretched to different lengths The linear relationship between the unbalanced force and the acceleration produced can be emphasised.

This experiment may be conducted in yet another way. The cart is attached to a pan through a long string passing over a pulley. The force may be applied by keeping some weights on the pan. The remaining procedure remains the same as in the preceding experiment. For accurate results it is necessary to determine balancing force first and take it into account for calculating unbalanced force in each case.

At this stage you can discuss the mathematical relationship between the change of momentum and the force applied.

Keep mass of the moving system constant. Can you give the reason for doing so ?

For the third law of motion you can first put the following questions and collect responses of the students. Diagrams may be drawn on the board to indicate the situations.

1. Two spring balances A and B are joined together through their hooks. Now force is applied to spring B keeping spring A at the same place. The reading of spring B becomes 200 g Will spring A indicate the same 200 g reading or less than it or more than it ?

2. What difference will it make if force is applied on spring A instead of spring B ?

3. Will there be a difference between the readings of the two balances if both are pulled apart simultaneously (by different persons) ?

Afterwards the students may be asked to do actual experiments and note the readings. The equality between action and reaction may be emphasized.

The following demonstrations are also very interesting and useful to develop the concept of action and reaction :

(i) Air is allowed to escape from an inflated balloon. The balloon moves in a direction opposite to that of the movement of air

(ii) A small amount of water is put into a pyrex test-tube. A cork is loosely fitted on the mouth of the test-tube and the test-tube is suspended horizontally using two loops of string over a bunsen flame. When the cork pops out the test-tube swings backwards

Thereafter you can ask the students to list the physical phenomena where the third law of motion is applicable. The students may be asked to pinpoint the action and the reaction separately. Using the responses of the students or through your own examples you can impress upon the students that action and reaction act on different bodies.

Afterwards working of jet planes and rockets may be discussed using simple diagrams.

It should be remembered that Newton's laws of motion hold good in an inertial frame and our earth is only a close approximation to an inertial frame. Also 'absolute motion' of a body is meaningless as motion is a relative term. Motion relative to some other object or material framework is of consequence to us.

Newtonian mechanics has stood the test of time in explaining our daily life experiences about motion, mass, force and acceleration, etc. But Einstein's theory of Relativity has given us more general laws of mechanics Newtonian mechanics may be considered as a special case of relativistic mechanics.

Let there be two frames of reference called systems S and S′, having axes x-y-z and x′-y′-z′ respectively and the origins being at O and O′ respectively Let the system S′ be moving with a velocity v along the positive x-direction of S. Let us begin counting time from the instant the origins O and O′ were coincident ($t=t'=O$).

According to the special theory of relativity the measurements of distance, time,

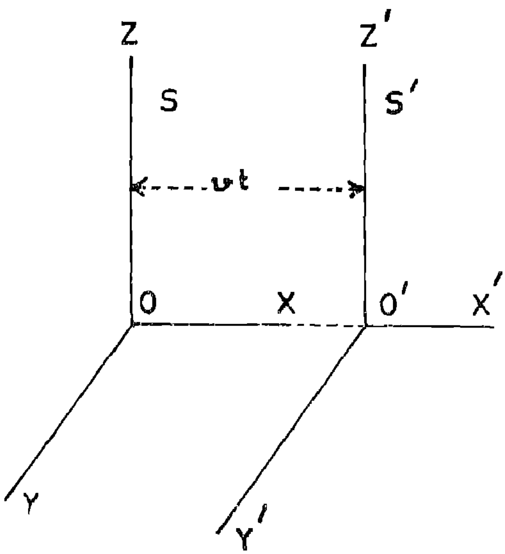

Fig. 29 1. Frames of reference in systems S and S'

mass, etc , will differ from one system to another. The Galilean-Newtonian transformations are to be replaced by another scheme of transformation first suggested by Lorentz and adopted by Einstein.

The Galilean-Newtonian Transformation	The Lorentz-Einstein Transformation
$x'=x-vt$	$x'=a(x-vt)$
$y'=y,\ z'=z$	$y'=y,\ z'=z$
$t'=t$	$t'=a\left(t-\frac{vx}{c^2}\right)$
	where $a=\frac{1}{\left(1-\frac{v^2}{c^2}\right)^{\frac{1}{2}}}$

If identical metre sticks and clocks (ticking seconds) were placed in each system initially they will no longer appear to be identical for observers E and E' in systems S and S' respectively. E will find that the metre stick of E' has a length $\sqrt{1-\frac{v^2}{c^2}}$ metre only i.e. it has shrunk Also E will observe that the clock of E' is ticking longer periods of $1/\sqrt{1-\frac{v^2}{c^2}}$ seconds i e the clock of E' is running slower. The observations of E and E' are reciprocal. E' will find the metre-stick of E to be shortened and the clock of E also running slower. The shrinkage-factor and the slowing factor are the same, $1/\sqrt{1-\frac{v^2}{c^2}}$ This is practically equal to 1 in ordinary cases where $v<<c$. It becomes significant if v is comparable with c.

According to the relativistic mechanics the mass of a moving body (m) is related to its mass when it is at rest (m_o) by the equation—

$$m=\frac{m_o}{\sqrt{1-\frac{v^2}{c^2}}}$$

The difference in m and m_o is insignificant at ordinary velocities but becomes significant when the velocity v comes closer to c as in the case of high speed electrons or positive ions in particle accelerators.

A mass m is equivalent to energy given by the equation

$$E=mc^2$$

Similarly velocities u and u' in the two systems are related by the equation

$$u'=\frac{u-v}{\left(1-\frac{uv}{c^2}\right)}$$

In relativistic mechanics mass also becomes a variable quantity. How does this affect the second law of motion ?

Method Used

In teaching this topic, what methods have been suggested. Demonstration of experiments, student activities or experiments, and/or discussion ? Examine the relative place of each. How do you select experiments for demonstration? Availability of apparatus and materials, visibility to all the students, possible magnification of the result—these are some of the considerations. How do you plan a demonstration ? Prepare a list of apparatus and materials required and collect them. Spare apparatus of breakables need to be kept at hand. Apparatus needs to be cleaned and tested to see if they are in working order. As you proceed with the demonstration, care has to be taken to see that it is visible to all students. Point out important things that they should observe and put questions to find out what they have observed. Alongwith demonstration, discussion has to be used to see that the students understand the relationships between the observations and make the generalisations leading to the principles or laws.

Select a topic where demonstration can be used and plan a lesson.

Assignments

1. Bend a curtain rail so that it assumes the shape ABC (in vertical plane) as depicted below :

Fig. 29.2 Bent curtain rail

Using a pencil keep a steel ball just below the end A (at point P) and then allow it to roll down. Mark the position of the point on BC upto which the ball rises.

Now bend the curtain rail so that it becomes similar to ABC′ and allow the ball to roll down from P. Again note the position of the point to which the ball rises on BC′. Repeat this by bending the rail still further. Does the ball always rise to the same point ? Give reasons in support of your answer.

2. Try to prepare a frictionless puck using a hardboard disc, a soda straw and a balloon. Move the puck over a smooth table by applying a little force using a finger and watch its motion. Does it move in a straight line ?

3 Collect relevant material about the Aryabhatta and Bhaskara satellites and display it by means of charts, figures, models etc.

4. Describe the different possible ways of measuring force implied by the definition of force.

Questions for Review

1. What is the main reason for using heavy flywheels on engines ?

2. For removing mud from our shoes we have to stamp our feet. Why ?

3 A mass of 1 kg is attached to the hook of a spring balance inside a lift but an observer finds the reading of the balance to be 1/2 kg only. Which of the following statements could possibly be true for accounting the observation ?

(a) The arrangement is at rest.
(b) The arrangement is being pulled upward at constant rate.
(c) The arrangement is moving down at constant rate.
(d) The arrangement is being accelerated upward.

(e) The arrangement is being accelerated downwards.

4. What unbalanced force is required to accelerate a 15 kg bicycle from 5 m/s to 10 m/s in 2.5 seconds ?

5. Does a change in the weight of a body necessarily mean a change in the mass of a body ? Explain your answer.

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CHAPTER 30

Conservation of Momentum

Introduction

In our daily life we come across several situations involving collisions, explosions, phase changes etc., that have tremendous importance in science, especially physics. It may be gas molecules exerting pressure on the walls of the container or quantum-packets of light knocking off electron from alkali metals or high energy particles colliding with the nuclei of some elements or a fire-cracker bursting with a bang or a bomb exploding in a war and so on. The forces involved may differ in details, the moving bodies may undergo drastic changes but one physical quantity remains totally unchanged during the collisions and interactions. This quantity is known as the momentum The law of conservation of momentum is a very general law applicable in the case of massive heavenly bodies as well as in the case of tiny elementary particles.

Major Concepts

The major concepts you may have to earn to teach regarding momentum are .

1. The momentum of a body is equal to the product of its mass and its velocity.
2. The impulse of a constant force $\vec{F}$ acting on a body for time Δt is equal to $\vec{F}$ times Δt
3. Impulse and momentum are vector quantities.
4. The impulse of a force acting on a body equals the resulting change in the linear momentum of a body.
5. In the absence of a net external force acting on a system the total momentum of the system remains constant regardless of any interaction between parts of the system.

Whenever you push or pull a body, you apply a force for a finite time. The subsequent motion of the body depends on the product of this force, F, and the time during which it is applied, Δt, which is called the impulse.

$$\text{Impulse} = \vec{F} \cdot \Delta t$$

$= m\vec{a} \,.\, \Delta t$ since $\vec{F} = m\vec{a}$

$= m \, \Delta \vec{v}$

$= \Delta (m\vec{v})$ assuming 'm' is a constant

Thus the effect of impulse is the change in vector quantity $m\vec{v}$, called the 'Quantity of Motion' by Newton and now termed as 'momentum'.

The law of conservation of momentum may be derived using Newton's third law. Suppose two bodies A and B collide for time Δt resulting in a change of momenta $\vec{p}_A$ and $\vec{p}_B$ respectively.

(Force on A) = — (Force on B) ... Newton's third law

(Force on A) . Δt = —(Force on B) Δt

$$\Delta \vec{p}_A = -\Delta \vec{p}_B$$

Thus

$$\Delta \vec{p}_A + \Delta \vec{p}_B = 0$$

The principle of conservation of momentum for an isolated mechanical system is also very important and may be deduced using Newton's law of motion.

Consider a system of particles labelled 1, 2 and 3 and so on each characterised by its mass and momentum. The system has a centre of mass at C. The changes in momenta are $\Delta \vec{P}_1$, $\Delta \vec{P}_2$ and $\Delta \vec{P}_3$...respectively when forces $\vec{F}_1$, $\vec{F}_2$ and $\vec{F}_3$. act on the particles for time Δt Since Newton's second law is applicable to all the particles we have

$$\vec{F}_1 = \frac{\Delta \vec{P}_1}{\Delta t}, \quad \vec{F}_2 = \frac{\Delta \vec{P}_2}{\Delta t} \text{ and}$$

$$\vec{F}_3 = \frac{\Delta \vec{P}_3}{\Delta t} \quad \vec{F}_4 = \ldots$$

Therefore $\vec{F}_1 + \vec{F}_2 + \vec{F}_3 \ldots$

$$= \frac{\Delta \vec{P}_1 + \Delta \vec{P}_2 + \Delta \vec{P}_3 + \cdots}{\Delta t} = \frac{\Delta \vec{P}}{\Delta t}$$

Total force acting on the system

$$= \frac{\begin{pmatrix}\text{total change in the} \\ \text{momentum of the system}\end{pmatrix}}{\Delta t}$$

According to the Third law of Motion the internal forces for all the particles cancel out. Hence the sum of the forces on L.H.S. is total external force $(\vec{F}_{ext})$ acting on the system.

$$\text{Hence } \vec{F}_{ext} = \frac{\Delta \vec{P}}{\Delta t}$$

We can conclude that the total momentum of the system changes in response to a net external force only. For an isolated system the external force $(\vec{F}_{ext})$ vanishes and consequently there can be no change in the total momentum.

Methods Used

You can introduce this unit by allowing your students to actually feel that it is really the product of the mass of a body and its velocity that has something to do with the difficulty of starting or stopping the body. Ask your students to push a table, drive a nail in a wooden block using a heavy and then a light hammer. Let them toss rubber balls up in the air to different heights and then catch them. You can think of a number of similar activities for children.

Afterwards you can pose thought-provoking questions to develop the concepts

noted earlier. Find the answers to the following questions :

1. You can increase the speed of a cyclist by pushing him, but can you increase the speed of a slow moving loaded truck by pushing it ? Give reasons for in your answer.
2. One can stop a ball coming to one's side but no one is prepared to try to stop a bullet of lesser mass fired from a gun. Why ?
3. While driving a nail in to a wall we use a heavy hammer and move it back for quite a good distance before hitting the nail. Why ?

If possible, you should collect pictures of rockets and jets and explain their working principles to your students. You can draw diagrams or sketches on the board and use them for discussion. The emphasis should be on physical principles involved and not on technical details or mathematical derivations.

It is very necessary that the students see for themselves that the law of conservation holds good. Some activities are suggested below :

1 Inflate a balloon. Keep its mouth closed by means of your fingers and put it (as shown below) on a table. Let students note the direction of the balloon's movement on allowing the gas to escape.

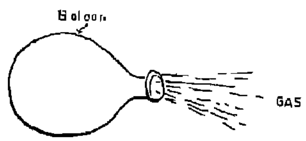

Fig 30.1 Gas escaping from a balloon

Now ask your students to repeat this activity keeping the mouth of the balloon in different directions.

2. Place five identical marbles in a smooth grooved board (or angle-iron) kept horizontally in a manner that each marble touches the next one Move the first marble to the left and strike it with a pencil so that it collides with the other marbles in front of it. Now all other marbles remain stationary but the last one moves with the same velocity with which the first one was moving. Why ?

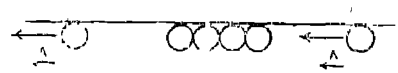

Fig 30.2. Collision of Marbles

Repeat this by taking 2 marbles to the left and then again taking 3 marbles to the left. Explain the observations

For quantitative verification of the law of conservation of momentum you need 2 carts, a spring, a smooth table, 2 bumpers (of wood), weights of different magnitudes, a chalk and a metre stick.

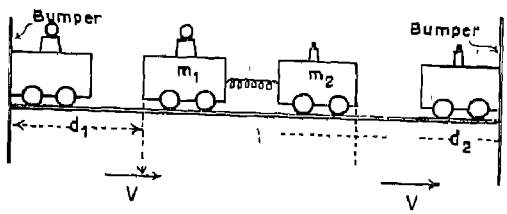

Fig. 30 3 Motion of carts for verifying the Law of Conservation of Momentum

Fix the bumpers at the ends of the table. Keep the carts in the middle with the spring pressed in between Place a starting mark for each cart at the end closest to the bumper. Release the carts and observe when they strike the bumpers.

Adjust the initial position of the carts so that they strike the bumpers at the same time.

If you know the mass of each cart and distance travelled by each at the same time you can prove the law of conservation of momentum.

It will be seen that

$m_1 d_1 = m_2 d_2$ (with usual notations)

Hence $\frac{m_1 d_1}{\Delta t} = \frac{m_2 d_2}{\Delta t}$ (time Δt is the same)

Since speeds are in opposite direction

$$m_1 \vec{v_1} = - m_2 \vec{v_2}$$

$$\text{or } m_1 \vec{v_1} + m_2 \vec{v_2} = 0$$

The initial momentum was also zero as the two carts were at rest. Hence the law is proved The experiment can be repeated keeping different masses on the carts.

Some sample questions that you may put to test the students' achievement are given below :

1. The momentum of a 0.01 kg bullet when it moves with a speed of 600 m/s is

(*a*) 6 kg m/s
(*b*) 60 kg m/s
(*c*) 6000 gm m/s
(*d*) none of the above

2. A 1500 kg car moving at a speed of 2 m/s collides with a truck weighing 6000 kg and standing at rest on a level surface. The two vehicles couple together on collision. The speed after collision is then equal to

(*a*) 0 4 m/s
(*b*) 40 m/s
(*c*) zero
(*d*) None of the above

3 A tennis ball of mass 509 moving at a speed of 6 m/s is struck by a racket. It leaves in the reverse direction at a speed of 10 m/s. What is the impulse applied to the ball by racket ?

(*a*) zero
(*b*) 0 2 kg m/s
(*c*) 0 8 kg m/s
(*d*) none of the above

4. A constant force produces an acceleration of 8 cm/s^2 in a body of mass 10 kg. What is the magnitude of the force.

(*a*) 8N
(*b*) .08N
(*c*) 8 dynes
(*d*) 1/8N

Method Used

What method of teaching do we adopt in teaching such topics in the school ? Firstly the concepts have to be developed by giving appropriate experiences to the pupils-getting a feel of mass, velocity, momentum and force. Secondly, relationships are discussed, and explained by applying known laws and principles. Thirdly, numerical examples are given to show application of these relationships.

Think of other topics where you can use such a method and prepare a teaching plan.

Assignments

1. Prepare a chart indicating the magnitude of the momentum of each of the following using the given data.

Object	Mass (*in kg*)	Speed (*in m/s*)
(*i*) Earth	6×10^{24}	3.0×10^{4}
(*ii*) Bullet	1×10^{-3}	2.5×10^{2}
(*iii*) Proton	1.67×10^{-27}	3.0×10^{5}
(*iv*) A loaded bullock cart	4×10^{3}	2.0
(*v*) Boeing 737 Plane	5.5×10^{4}	2.5×10^{2}
(*vi*) A railway engine	4×10^{4}	1.5×10

2. Describe an experiment to show that momentum is conserved even if the motion of the bodies is not confined to the same straight line before and after the collision.

3. When a horse pulls a tonga, the tonga exerts the same force on the horse as horse does on the tonga as demanded by Newton's third law. Explain how they move forward if the above statement is true. Describe all the forces coming into play in this example.

4 Comment on the statement—'Any attempt to pull or push leads to two forces or none'.

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CHAPTER 31

Refraction and Dispersion

Introduction

The apparent bending of a stick under water, apparent lowering of the depth of a tank and the colourful rainbow, constitute the day-to-day illustrations of the phenomena of refraction and dispersion of light. If you use pins, drawingboard, glass slab, prism and some geometrical drawings to illustrate, it gives sufficiently good results, but does not demonstrate the bending of light in a direct manner. In the following pages we shall discuss the teaching strategy to be employed for the effective learning of these phenomena of light. Mostly demonstration, pupil activity, and demonstration-cum-discussion method have been illustrated.

Major Concepts

The major concepts in this unit are as follows :

(*i*) Light ray changes direction when it passes from one medium to another.

(*ii*) For a given ray and a pair of media the ratio between sin i and sin r is constant,

(*iii*) White light can be dispersed into its components when it passes through a prism.

Consider a plane wavefront AB incident on a boundary between two media R and D at an angle other than normal incidence.

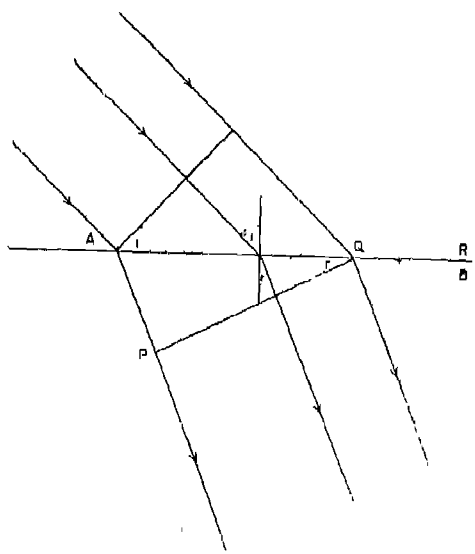

Fig. 31.1, Refraction of light

R is a rarer medium and D is denser Assuming that light travels slower in the denser medium waves from A will travel a lesser distance AP in D in the time in which waves travel from B to Q in R. Thus PQ will be the resultant wavefront in D, defining the angle of refraction r. We have

$$\sin i = \frac{BQ}{AQ}, \quad \sin r = \frac{AP}{AQ}$$

$$\frac{\sin i}{\sin r} = \frac{BQ}{AP} = \frac{\text{velocity in R}}{\text{velocity in P}}$$

$$= \text{constant} = \mu$$

What happens when i = o ?

When light travels from a denser medium to a rarer medium it can be similarly shown that it bends away from the normal As the angle of incidence θ increase the angle of

What is the relationship between θc and μ? What value for sin r is predicted by Snell's law for θ — θc ?

The phenomenon of refraction occurs because the velocity of light is different in different media. The extent to which a ray will be refracted not only depends upon the medium, but also on the wavelength, hence on the colour of light. Therefore, when white light goes from one medium to another, it is split into various colours (wavelengths). In case of a parallel slab of the intervening medium such different deviations for every colour get annulled separately at the second boundary. Hence all the separate coloured rays recombine to form white light. When the intervening medium is bounded by two inclined surfaces as in case of a prism, the separation between colours produced at one interface

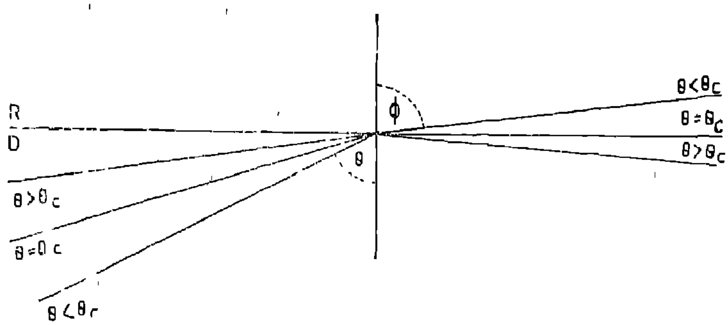

Fig. 31.2 Total internal reflection of light

refraction ϕ also increase till it becomes 90° giving sin ϕ=1. If you further increase ϕ, light is completely reflected back into the denser medium. The angle of incidence for which angle of refraction in rarer medium is 90° is called critical angle ϕ_c.

gets enhanced at the other and when light emerges out of the second interface, it is in the form of a solar spectrum.

The three questions that you will like to answer in the teaching/learning of physics are. What ? How ? and Why ? Whereas

the first two about refraction are demonstrable by experiment the answer to the third one demands an explanation (in terms of arguments) for relating refraction to the earlier knowledge about light. In case of mechanical waves, it is understandable that their velocity should be different in different media because of the difference in coefficient of elasticity; elasticity being the measure of how fast the medium can respond to any disturbance. In the case of light or electromagnetic waves which do not require any medium for propagation, the medium effects the velocity because of the fact that every material medium is electrical in nature and the electric and magnetic fields effect the electrons of the medium which in turn effects the speed of these electromagnetic disturbances.

The speed of light is less in the denser medium is also a proof against the corpscular theory of Newton. If light were particles as propounded in corpuscular theory, their bending towards the normal while entering a denser medium would require their velocity to be higher which is contrary to experience.

Prove that a particle going through a medium, in which its velocity is higher, bends towards the normal.

Method Used

(*i*) Light ray changes direction when it passes from one medium to another

From the knowledge already acquired it is assumed that pupils know that light travels in a straight line in a homogeneous medium. This is to be made sure first. This can be done by asking questions or by actual demonstration of beams of light in a smoke box or a ray apparatus. The experience of the pupils with sunlight coming through a small hole can also be recalled. In the discovery method, pupils may be left with the ray apparatus (or they may be asked to make one) and see for themselves what happens if you intervene some medium say water in the beam of light so that it is incident at some angle. If ray apparatus is not available, they may be encouraged to do the following activity in a group of at least two pupils.

Activity Let a small beam of light come from a bulb through a hole in a dark room A beam of sunlight coming through a hole in the window of a room will also serve the purpose Now ask one pupil to hold a rectangular bottle filled with water in the light beam. Ask another pupil to put a very small amount of colour or any other material which will remain suspended in water and also to sprinkle some chalk dust in the paths of the beam outside the bottle. Let all the students observe carefully what happens if the tilt of the bottle is changed.

In the above activity, no quantitative measurements can be made but through actual observation and group discussion afterwards, the concept that light bends when it goes from one medium to another, can be brought home very effectively.

After this direct demonstration, the phenomenon of bending of the stick, apparent depth of a tank can be interpreted through lecture-cum-discussion method. Problem-solving method may be used for illustrating the world view of fish inside the water

For teaching the second concept, the ray apparatus with provision to measure angles will be most suitable. If this apparatus is not available then the standard

experiment with pins and glass slab can be performed by the pupils. How the line joining the two pins on one side of the slab represents a particular incident ray should be explained. The same holds good about the emergent ray The logic involved in drawing the refracted ray should also be clearly stated. The pupils may be asked to tabulate their results in the form of angles of incidence and refraction And they may be encouraged to discover the relationship between the two

Testing Pupils' Achievement

Some typical questions are given here to test whether the pre-assigned objectives are fulfilled or not ·

1. Define refractive index.
2. If the refractive index for olive oil and air is 1.47 find out the angle of incidence in air, for an angle of refraction of 30° in the liquid.
3. What is normal at the point of incidence ? Can it change from point to point for a surface ? Explain.
4. The critical angle of water is 49°. What will happen to the light passing from water to air, if it is incident at the angle of 52° and 40° ?
5. List all the examples in everyday life where you see the rainbow colours. Try to explain their origin in each case.
6. Why do the pins as seen through the prism look coloured ?
7. Try to see the pins through different colourless transparent objects. Through which objects the pins look coloured ? In what way these objects are different ?

Method Used

The discovery method is stressed in this chapter. What kinds of relationships do you expect pupils to discover without spending too much time ? Some discoveries took several years of the scientist's time. May be the pupils should not be allowed to spend too much time to discover the same independently. You should be careful to ensure that it does not waste the pupil's time. For example the pupil may be let alone to 'discover' the angle of incident is equal to the angle of reflection Would you also let the pupil 'discover' that in the case of refraction aims of the angles of incident and refraction are related ? What hints would you give them so that they see this relationship without spending too much time. You may make a list of topics that can best be taught by discovery method together with the hints to be given to the pupils.

Assignments

1. List as many illustrations of 'total internal reflection' as possible.
2. How will you dispel the doubt of a pupil who says that the colours in the solar spectrum are produced by the prism ?
3. List all the sub-concepts in Refraction which can be taught through discovery method.
4. Make a ray box. Try to use it to illustrate that the incident ray, the refracted ray and the normal at the point of incidence are in one plane.
5. Make a Newton's disc
6. Write a small paragraph to explain the occurrence of rainbow to your pupils.
7. In what way can you make use of the ripple tank for teaching this unit ?

8. Write a few lines to explain the phenomenon of mirage to your pupils. Can you think of some illustrations from daily life ?
9. What can you deduce about the nature of light from the following observations ?
   (*i*) Light in general gets partly reflected and partly refracted at an interface
   (*ii*) Light beams cross each other.
10. What activities you will perform to convince the students that it is the diffuse reflection which makes things visible
11. Will you think of replacing the pupil activity method in the text with some other method ? Discuss the situations when you will like to do so with respect to merits and demerits of the particular method

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CHAPTER 32

Some Applications of Physics

Introduction

The present century has seen some of the most spectacular applications of principles of physics. Starting from the advances in space exploration to the discovery of the structure of elementary particles such as protons and neutrons, the applications of physics have become innumerable. In modern home the application of physics can easily be seen. One often sees people listening to the cricket test match commentary using a transistor set. There are other applications of physics in developing communication devices such as radios, televisions, amplifiers, microphones, transmitters, radars and sonars In the present unit the principles underlying some of these communication devices will be studied. The demonstrations may require more sophisticated equipment than may be ordinarily available in the schools. You may try to obtain some components from junk (Kabari) electronics shops and use them for demonstration. For instance if you find an old discarded radio you get the triode, speakers etc. from it to build suitable teaching aids. You will thus develop skills in improvisation. If an oscilloscope is available you may use it to develop skill in showing rectification, pulses from microphone, amplifier action, and modulation.

Major Concepts

1. A.C. can be converted to D C. by using a diode.

2. Sound can be converted to electrical pulses and vice-versa.

3. The loudness of sound can be increased using an amplifier

4 Sound waves can be carried from one place to another with a 'carrier' known as radio frequency waves which can travel long distances.

5. Waves can be reflected from an obstacle,

Illustration of Concepts

1. To develop the concept of conversion of A.C. to D.C , the principle behind diode rectification may first be explained. You may explain thermionic emission and formation of space charge giving suitable analogies. For example, when we heat water some molecules 'boil off' and form vapour. Similarly when we heat metals, which contain large number of free and loosely bound electrons, the electrons 'boil off' and form a cloud. Just like the vapour pressure is exerted on the water surface, the electrons in the cloud exert repulsive force on the electrons trying to 'boil off' the metal. Finally a state of equilibrium is reached when the number of electrons emitted by the metal is equal to the number of electrons repelled into the metal surface per unit time. You may then indicate that in diode we introduce the plate and apply potential difference between the emitter and anode You may have the students suggest that

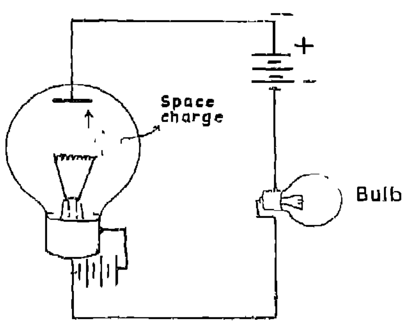

Fig. 32.1 Rectification by diode

the electrons, from the space charge around the emitter, will be attracted to the anode only when it is positive with respect to emitter thus causing current in the circuit as shown in figure 32.1. You may also ask the students whether there will be any current when the anode is negative with respect to the emitter. Give them a demonstration using the circuit shown in fig. 32.1. The bulb will glow only when the positive terminal of the battery is connected to the anode It will not glow when the negative terminal is connected to the anode. Then ask your students what will happen when instead of a battery you connect on A.C. source. The diode will conduct during the positive half cycle and not during the negative half cycle, thereby rectifying the wave. If an oscilloscope is available you may show the full and rectified waves to the students.

2. Next, you may discuss amplification by a triode by introducing the extra element of grid to the diode. You may mention that since the grid is closer to the space charge its voltage is more effective in controlling the space charge. When the grid is negative with respect to the emitter the space charge is repelled away from the plate and when the grid is more positive with respect to emitter the plate current is much increased. Small changes in grid—emitter voltage cause enhanced changes in plate current therby amplifying the signal.

Draw a circuit diagram of a triode amplifier.

3. The conversion of sound to electric pulses may be illustrated by improvising a simple transmitter-receiver system as shown in figure 32 2. A diaphragm is placed on carbon granules in which two nails are stuck as shown. The sound waves make the diaphragm vibrate changing the pressure on carbon granules thereby changing the

resistance between the nails. These changes in resistance cause similar changes in the current. Thus sound waves are converted to electric pulses (or waves) These pulses are converted back to sound in a distant receiver As shown in the figure, these pulses pass through a coil and modify the magnetic field between the coils and the magnetised razor blade, thereby making the razor blade vibrate reproducing the original sound.

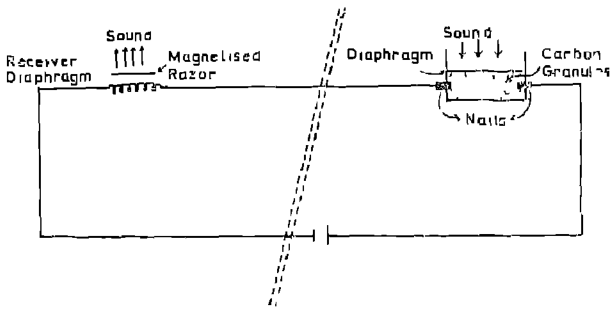

Fig. 32 2 Simple transmitter receiver system

Make a simple model of telephone transmitter-receiver similar to the one described above for demonstration.

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4. To illustrate amplification of sound you may state that sound is first converted to electric pulses which are amplified by a triode and triode converted back to louder sound, as discussed above.

5. You may give the concept of modulation by giving examples such as carrying of wooden logs by the flowing water in rivers. If an oscilloscope is available modulated and component waves may be shown to the pupils.

Evaluation of Pupil Achievement

Questions .

1. A radio signal is sent to detect the presence of an aircraft. It comes back to the ground in 0 002 seconds. What is the distance from the base to the aircraft? The velocity of radiowaves is 3,00,000 km/s.

2 Draw a labelled block diagram of a radio broadcast transmitter

3 Explain with the help of a block diagram the working of a radio receiver

4. Explain what is meant by 'rectification' and 'amplification'.

Method Used

In this chapter lecture-cum-demonstration method is used. Pupils learn better by doing and therefore some activities are also suggested You may encourage pupils to get their 'hands dirty' by doing more activities using improvised apparatus. Which simple activities would you suggest? The pupils may be asked to play with discarded electronic apparatus whereby they gain more understanding of the topics discussed in this chapter. You may yourself assemble

improvised apparatus and demonstrate it to pupils taking all the suggestion of Chapter 18 into consideration. You may be able to get new ideas about what and how to improvise from popular electronics books. You can really get pupils interested in popular topics of this chapter. Once you generate interest in pupils you may then have them read further on their own. How will you use self study method more extensively in this unit ? Try to prepare some more self study material for this chapter

Assignment

1. Prepare self-study material to describe the working of a television set.
2. Explain the working of a simple oscilloscope.
3. Draw labelled block diagrams of radio receiver, transmitter, public address system showing the changes in waves as they go from one block to another
4. Draw the diagram of a simple microphone and explain its action
5. Try to obtain a discarded microphone and identify its parts. Draw a diagram of the same for pupils ?

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CHAPTER 33

Electricity

Introduction

Electricity has effected many people's lives more than any other branch of physics. Electric energy is a dominant factor in television, telephone, radio and other communication devices Man's ability to control and deliver vast amounts of electric energy has resulted in the development of appliances such as heaters, cookers, air-conditioners, etc, which are becoming popular in the urban areas In this chapter the discussion starts from electrostatics, the science of stationary electric charges. Electrostatic forces are inherent in the study of atomic and molecular structure. The discussion on electricity, the science of moving charges, and electric circuits are also included. It is primarily because of these many applications that the pupil's interest may be aroused in this subject You may further motivate them by giving demonstration using a live circuit.

Major Concepts

1. The force between two electric point charges is directly proportional to the product of charges
2. The force between two point-charges is inversely proportional to the square of the distance between them.
3. The space around an electric charge acquires a new property by which it exert a forces on other charges.
4. An electric charge in an electric field possesses potential energy
5. Current is the rate of flow of charges through a cross-section of a conductor.
6. The current through a conductor is proportional to the potential difference across its ends, provided the physical conditions remain unchanged.
7. Resistances can be combined to get a new resistance.
8. Power is consumed when charges flow in an electric circuit.

Illustration

1. To illustrate the first two concepts 'The force between two electric charges is directly proportional to the product of charges and inversely proportional to the square of the distance between them', you may use the lecture-cum-demonstration method. This concept may be developed to the application level.

In the demonstration use is made of two pith balls (or balloons) suspended by light strings When given like charges the two balls repel each other If more charge is given to these balls keeping the points of suspension unchanged, the balls will tend to go farther apart indicating greater repulsion. Thus the force varies directly with the charges. Again if the magnitude of charges remains same and the points of suspension of charges are varied, the inverse dependence of force on the separation can be demonstrated. However to show that the force varies inversely as the square of separation, detailed laboratory experiment must be performed by the student.

The expression for Coulomb's law in M.K S. and S.I. Units is $\vec{F}=K\frac{\vec{r}}{r^3}q_1 q_2$...(1) and the unit of charge (Coulomb) is defined independently of this law. However, in the C. G. S. system, which is used in reference books, the expression for Coulomb's law is $\vec{F}=\frac{\vec{r}}{r^3}Q_1 Q_2$ . .(2) and the unit of charge (statcoulomb) is defined using this expression. Thus if $Q_1=Q_2=Q$ and $r=1$ cm then $Q=1$ statcoulomb if $F=1$ dyne Thus one statcoulomb is that charge which repels an equal charge, at a distance of one centimeter, by a force of one dyne.

Do the dimensions of Q in SI and CGS systems involve only M, L and T ? Comment.

2. To develop the concept of current you may indicate that if a cell is connected across the ends of a conductor, an electric field is set up inside the conductor by the charges on the plates of the cell This electric field exerts force on the electrons of the conductor resulting in net transfer of charge across any cross-section of the conductor. The rate of flow of this charge is called the current

How does the current depend on the area of cross-section, number of charged particles per unit volume of the conductor, electronic charge, and drift velocity ?

You may also give hydraulic analogy. Water in a pipe moves because the pressure behind is greater than the pressure in front as in Figure 33.1. Similarly there is net flow of charge in a wire only when there is a potential difference across it.

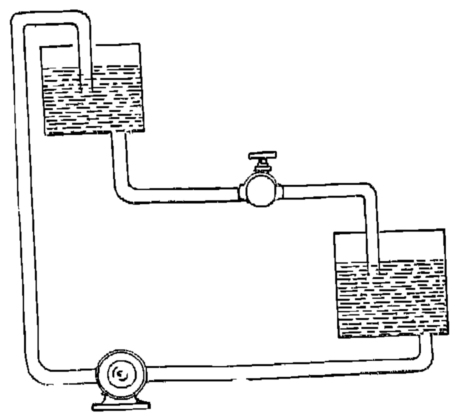

Fig 33.1. Hydraulic analogy

Draw an electric circuit analogus to Fig 33.1. How will you use these to further illustrate the concept of potential difference ?

You may also stress that in the process of charging batteries work is done on the additional charges to be given against the force exerted by the charges that are already on the plates. This total work done results in charging the battery. Thus a charged battery has energy. When this charged battery is placed in a circuit it makes charges flow thereby losing energy. This current produced is used to light bulbs and in heaters The rate of loss of this energy is the power consumed. The concept of power may also be broughtout indirectly by the amount of heat generated. You may show heaters or bulbs of different powers to the students and experience that the higher power heater generates more heat You may emphasise that the work done on the circulating charges in the coil of a heater appears as heat. This work is, of course, q_V and therefore the power or the rate of doing work is $\frac{q}{t}V$ or i_V or i^2R. Thus, you may have your students measure the resistance of different heaters to show that the high power heater indeed has smaller resistance.

Compare the resistances of a 1000 watt and a 500 watt heater. How much will it cost to use the 1000 W heater for 8 hours provided 1 Kwh of electricity costs 25 paisa ? The above problems may be discussed and solved in the classroom.

Evaluation of Pupil Achievement

1. Calculate the electrostatic force between two small insulated objects having a charge of 2.0 and 4.0 coulombs and placed 50 cm apart ?
2. If the distance between two charges is doubled, the force between them would become
   A doubled
   B. halved
   C. one-fourth
   D. four times
   E. remain unchanged
3. In an electric field, the work done in moving a unit positive charge between two points is the measure of the
   A. power
   B. potential difference
   C current
   D resistance
4. Plot a graph between V and I from the following data and interpret it
   I (in ampere) 0.555 0.110 0.170 0 230 0.295 0 325 0.590
   V (in volt) 1.30 2.60 4.00 5.45 6 95 7.70 9.20
5. Four 2 ohms resistances are connected in series with a battery of 6 V. What is the current ? If the resistances are connected in parallel in the same circuit, what will be the current ?
6. A 60W lamp is connected to 110 V mains What is the current in the coil of the lamp ? What is the resistance of the coil ?
7. Three resistances of 5, 15, 30 ohms, respectively are connected in parallel across a 12 volt battery. (a) Find the combined resistance, (b) Find the current through each resistor ; (c) Find the total current drawn from the battery.

8 Calculate the cost of running your classroom fans during the school hours.

Method Used

In this chapter again the lecture-cum-demonstration method is used Therefore. connection with the previous chapters may be used. But in addition, demonstration using a live circuit is to be given For doing this you may practice before you go to the class. What should be the range, size and accuracy of the meters used for demonstration ? You will have to find out the answer to this and other similar questions. You may ask your pupils to give an estimate of the sizes of measuring apparatus, such as a galvanometer, used for demonstration in a class of about 40 students. You may also practise drawing a graph on the blackboard using the data obtained in the live demonstration experiment. A demonstration size geometry box may help you in showing how graphs are drawn.

You may take your pupils to the laboratory to take data and prove that the force between two charges is inversely proportional to the square of their separation. It may be a good idea to write a laboratory instruction sheet to guide the pupils After doing these experiments the pupils may also be asked to write instruction sheets for similar experiments.

Assignment

1. Charges A, B and C of +10, −12, +20 coulombs respectively are arranged as shown in Fig. 33.2. Find the force on charge A
2. Distinguish the difference between potential and potential difference.
3. What is the resistance of an electric lamp that uses 10 amp when connected to a 115 volt line ?
4. Find the current through 2Ω, 4Ω, and 10Ω resistors in the circuit shown in Fig. 33 3.
5. It is desired to give a demonstration of direct proportionality of current and voltage to a class. What type of ammeter and voltmeter (specify range) together with suitable resistance and cell will be needed ? Practice giving such a live demonstration of taking the reading and plotting a graph on the blackboard in the presence of students.

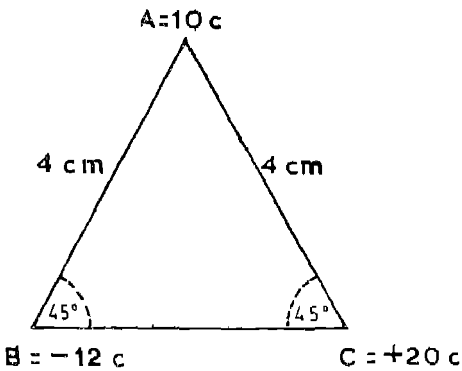

Fig. 33.2. Arrangement of charges

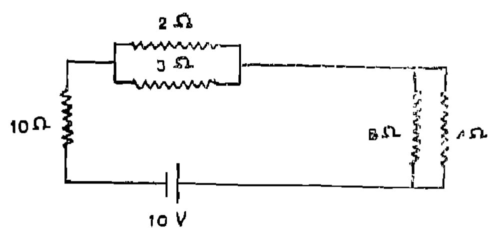

Fig. 33.3. Electrical circuit

6. Prepare a self-study (laboratory) worksheet for the pupils to verify that the force between two charges varies inversely as the square of separation between them.
7. Give suitable analogies to series and parallel combinations of resistances.
8. List the precautions you would take to demonstrate the presence of electric field using an electroscope when the weather is damp.

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CHAPTER 34

Universe

Introduction

Scientific approach to the study of the universe was undertaken in India by Aryabhatta and others during the 5th century A.D. Tycho Brahe took painstaking observations of the sky for a long period of time and recorded a number of scientific observations. These observations helped later astronomers to analyse and classify them and also to form some generalizations. One must know that astronomy is not an experimental science as other branches but mainly an observational one. The introduction of Galileo's telescope in 1609 and the rapid progress in the design of new telescope helped the astronomers to carry out such observations more precisely. The modern Multiple Mirror Telescope at Mt. Hopkins is an example of the type of development in the instruments used by modern astronomers.

You should have an experience of field study to understand the relative motion of heavenly bodies in the sky. Pupil teachers are made to gaze at the sky at night to get firsthand experience of movements of stars and planets. Keen observation is the first step in scientific endeavour which gives the pupil an opportunity to notice keenly the direction of motion of the constellations, moon and planets Keeping in view the INQUIRY approach a few observational data as well as figures indicating the picture of a section of night sky during the first week of four successive months are provided to interpret the data and help in generalization through critical thinking and reasoning. In order to understand the phenomenon of 'phases of moon' a simple pupil activity is suggested and, similarly a model of celestial sphere is to be prepared to know the motion of heavenly bodies. A few higher concepts of nebula, motion of galaxies, inter-stellar inter-galatic space, and stellar evolution are included.

Artificial satellites have given the scientists a new tool to help mankind in

improving the communication system, in the study of meteorology and also in geological prospecting of the earth. The advancement in space travel has opened a new sphere of activity and we have far better knowledge of our planets by photographing them at very close quarters Man hopes to probe the interstellar space through manmade space vehicles and obtain precise and authentic informations in the near future.

Major Concepts

1. Study of the sky night after night for a long period will show the relative motion of heavenly bodies.
2. The constellations seem to set in the west
3. The planets, the sun and the moon seem to move towards the east relative to the constellations
4. Inter-galatic distances have a magnitude of millions of light years
5. The interstellar gaseous substances condense under their gravitational pull.
6. Stars cease to emit light and heat when the nuclear fusion stops.
7. The gravitational pull of the huge mass of a 'dying' star may even 'crush' atoms
8. Artificial satellites help man in improving communication system, in the field of meteorology and in geographic and geological survey of the earth.
9. Interplanetary vehicles have widened man's knowledge of the solar system.

Concepts 1 to 3 are taken up for detailed study of content-cum-methodology.

Concept 3 Light year (9.46×10^{12} km) is used to indicate the distance between stars and galaxies The nearest star is about 4.35 light years and the nearest galaxy is about 2,000,000 light years from the sun.

Our galaxy is disc-like having a diameter of about 100,000 light years and its central part has a thickness of about 10,000 light years In the Universe there are a very large number of galaxies. With the help of 200" telescope man could photograph galaxies which are assumed to be at 5×10^{9} light years. Radio telescope could scan up to a distance of 10^{22} which is equivalent to about 10^{10} light years

Concept 4 Photographs of certain stars indicated some scattered patches of light, for example, the photographs of Andromeda, Crab Nebula, etc. The brightness of these patches of light seem to vary. Wherever the brightness increases suddenly they are called as Nova and some times Supernova Such sudden increase in brightness is due to explosions of stars. The Crab Nebula in Taurus constellation is found to be exploding as the scattered light is expanding. The explosions will naturally leave debris.

The observational evidences and the theoretical considerations indicate the evolution of stars from inter-galatic gaseous substances. In millions and millions of years these gaseous substances condense due to gravitational pull to form a new star. The gravitational pull makes the matter come closer and closer introducing enormous heat at its central part.

Concept 5. Scientists have reasons to believe that in the sun there is continuous fusion taking place giving rise to large amount of heat. This heat helps protons to fuse to form helium nuclei with production of still higher amount of heat. So it

is assumed that in stars fusion must be taking place continuously to produce enormous amount of heat.

Indicate how the fusion of protons takes place in the sun to produce helium nuclei as well as heat.

Concept 7 : You can have a picture of what would happen when fusion ceases. The stars will not be able to emit heat and light and become 'cold'. The gravitational pull will try to reduce its enormous size. This again may increase the heat and in millions and millions of year the gravitational pull will reduce the size of stars

Try to find more information by referring to some science journals on 'Black Hole'. The gravitational pull will be so great that even light photons will be lost completely

Concepts 8 to 9 : Student-teachers may refer to 'Science Today' and 'Science Reporter' and gather information about space flight, flight to the moon and also inter-planetary rockets such as Pioneer, Mariner, etc.

1. Location of Dhruva Tara and Sapta Rishi and the orientation of constellations.

If you look at the sky during the night you observe a very large number of shining bodies of different sizes differing in brightness and even in colours Most of them are known as stars and a few as planets. The moon is also seen in the sky with different phases depending on the day and month. To a naked eye on a clear night with no moon, one can see about three thousand such heavenly bodies.

How can you estimate the upper limit for the number of stars seen by naked eye ?

But it is too difficult to mark them as the light entering one's eye will be too small. However, if a person uses optical instruments such as telescope or binocular, he can easily see more such shining bodies With 40″ telescope we will be able to collect about 2,000 times as much light as the naked eye The largest optical telescope with 200″ reflecting mirror at Mount Palomar will be able to collect about 640,000 times light as much as the naked eye So the optical instruments and other modern astronomical instruments help a person to study the sky in detail. Modern technology has made it possible to scan any particular part of the sky continuously for hours together.

If you look at the sky night after night for some weeks you will notice stars etc. rise and set They all seem to revolve or wheel through the 'heaven' in an orderly and systematic manner. It is interesting to note that even though the stars rise and set at night they maintain the same arrangement among themselves. Groups of stars which keep up the same arrangement among themselves are generally called Constellations.

Field study of gazing the stars

You already know the difference between constellations and planets, etc. Now plan an activity to gaze the northern sky during the night. You must have an idea about the latitude of your place which you can find from a map of India Plan the field study of gazing the sky on a tarrace so that you can clearly note the northern horizon. Look at the sky at an angle of the latitude, for example, if the latitude is 13° make sure that the northern horizon

and your eyesight make an angle of 13° You will notice a star in that direction which is known as Polaris and in India as Dhruva Tara. As stated earlier constellations seem to revolve or wheel through heaven. But this particular star seems to be stationary.

Why does this star seem to be stationary in the sky ?

One knows that the earth rotates about its own axis from west to east

How would you make the children know the different orientations of the Sapta Rishi during different hours of the night ?

You can now prepare a model of Celestial sphere and mark the Polaris, Big Dipper and other stars.

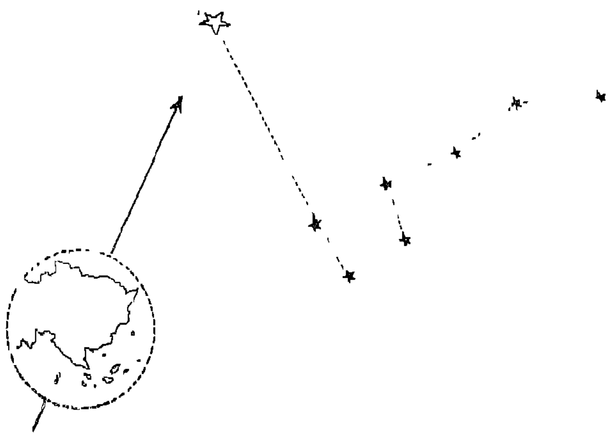

Fig. 34.1. Rotation of the earth and the position of the Polaris and Sapta Rishi as seen from outer space.

You can use the figure 34.1 to explain why the Polaris does not revolve in the sky. A group of stars are seen close to the Polaris as shown in the figure 34.1. This constellation is known as Ursa Major and commonly known as Big Dipper (Sapta Rishi) as it looks like a dipper In India it is called Sapta Rishi.

How can a person locate the Polaris with reference to the Big Dipper ?

Preparation of a model

Activity : Take a large round bottom flask of about a litre capacity. Fill it half with blue coloured water. Fix one holed rubber stopper through which pass a glass rod so as to touch the bottom of the flask Clamp the arrangement with its mouth facing downward as in figure 34.2. Make the

inclination of the rod same as the latitude of your place.

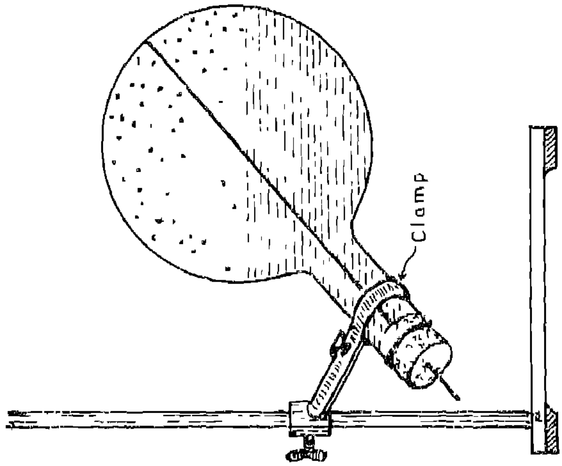

Fig. 34.2. The celestial sphere model

Where are you going to mark the Polaris ?
How are you going to locate Sapta Rishi and other stars ?
In which direction are you going to rotate the sphere ?
What does the plane of blue water indicate ?

When you rotate the flask, note whether all stars seem to rise from the horizon. Pay attention to the constellations near the Polaris and others marked near the central part of the flask.

Plan an activity so as to make the children draw the Sapta Rishi as seen at 8.00 p m. and morning 5 00 a.m. with reference to the Polaris.

2. Zodiac belt and movement of constellations, planets, etc.

The Zodiac belt is about 16° wide. The sun, the moon and planets like Mercury, Venus, Mars, Jupiter, Saturn, Uranus, and Neptune seem to move on this belt. The outermost planet viz. Pluto does not follow this belt due to its greater inclination of orbit. Refer Fig. 34.3 which shows the orbits of the planets as seen edgewise.

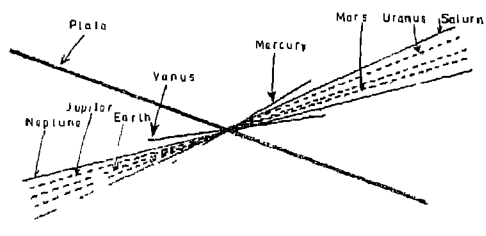

Fig. 34.3. Orbits of the planets edgewise

Field Study-Cum-Inquiry Method

When a person looks at the sky for a long period of time say for months together he will notice slight changes in the positions

of the stars. These changes cannot be detected by studying the sky on successive nights. The positions of a few constellations between July 1979 to October 1979 are given in figures 34 4 to 34.7. Remember that we are looking at a small section of northern sky, that too towards west. But the sky will look like a hemispherical globe known as celestial sphere Stars close to the Polaris i e., towards the northern point seem to appear as smaller circular orbits whereas the stars near the central part of the celestial sphere will appear as larger orbits. But all these stars rise and set during the night on semi-circular paths from east to west. Naturally the speeds of apparent motions will vary.

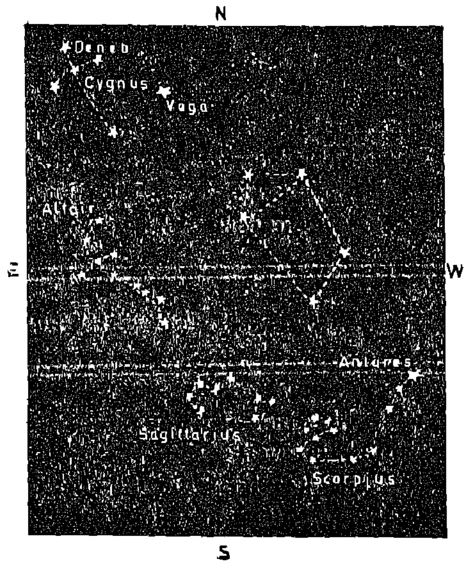

Fig. 34 4 Towards the south-west Scorpius constellation is seen with a bright star known as Antares To its east Sagittarius is seen with many bright stars. This constellation happens to be at the south of our field of view.

Towards north we see a brilliant white star known as Vega. To its east and in our field of view towards north-east we see a bright constellation known as Cygnus (Hamsamandal) with a bright star known as Deneb Beneath this constellation you will see a bright white star known as Altair.

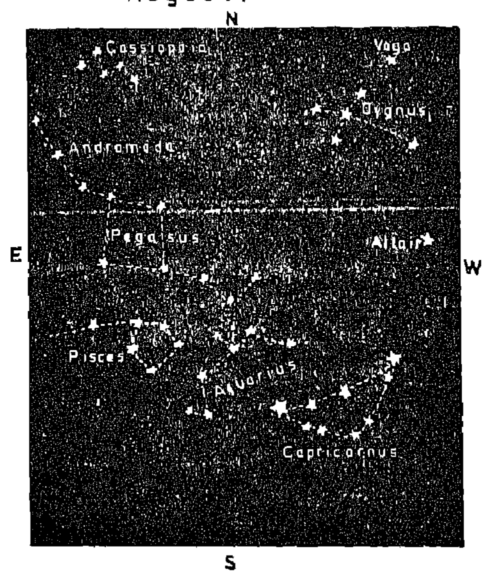

Fig. 34.5. You see a brilliant white star Vega towards north-west direction Close to it toward its east you notice Cygnus, the Swan constellation with the bright white star Deneb.

Towards north-east you see Cassiopia constellation Beneath this you will notice Andromeda with bright stars

Towards west you notice the bright white star Altair.

Towards east you will notice the great square known as Pegasus

Capricornus is seen towards the south which resembles farmer's (inverted) hat Aquarius is seen to its east. The stars of this constellation are faint A part of Pisces is also seen towards east.

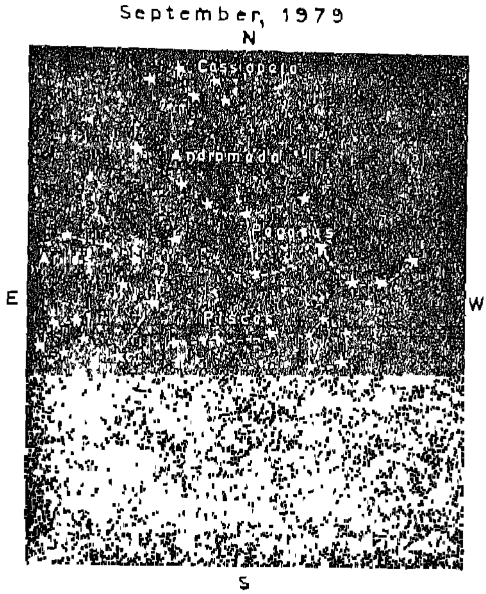

Fig. 34 6 Cassiopia is now seen towards north. Andromeda is seen just beneath it with the great square Pegasus having bright stars.

The constellation Pisces is seen at the centre of the field of view with its Circlet Aries will be at the east having a bright star

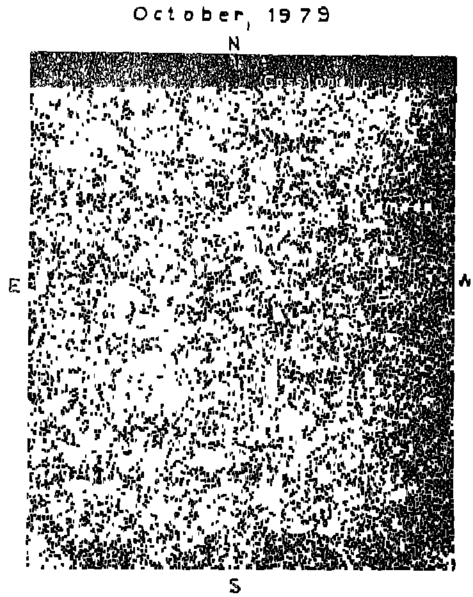

Fig. 34.7. Cassiopia is now seen towards north-west Below that Andromeda is seen Towards east of Andromeda you will notice one very bright white star known as Capella

A part of Pisces constellation is seen towards west To its east you will notice Aries having one bright star Taurus constellation can be seen nearly at the centre of our field of view having one bright yellow-orange star known as Aldebaran (Rohini).

Note · Figures 34 4 to 34 7 represent a small section of the night sky taken at about 7.30 p m If you wish to read the sky hold the chart over your head so that the cardinal points like east-west and north-south are properly oriented. Use a binocular for better and clear view of the sky Refer to some of the important bright stars the chart to identify the constellations

What do these data indicate ?
What generalisation one could draw from these data ?
Can you suggest the position of Taurus constellation during the first week of November 1979 ?
Name the constellations which are seen in the west during the months of July and August ?

You can notice the movement of these constellations towards west. In other words, these constellations do not appear in the sky at a fixed position at any definite time of the night. The constellations, Scorpius and Sagittarius, move westward and are completely out of the field of view in a month and again during

the next month Capricornus and Aquarius move out of the field of view. During the third month you will notice that Pisces and Aries are seen but they do not exactly occupy the positions of earlier constellations. In October Aries moves towards the west and Taurus is seen prominently in the field of view.

The seasonal changes of the positions of these constellations show that the movement is cyclic in nature. You may remember that astrologers correctly predict the positions of various constellations to be associated with different planets, the moon and the sun. It is known that each constellation has a length of 30° and constellations shift about 30° westward in each month.

Pupils' Activity Method

Activity · In order to make the children observe and identify a few stars and constellations and also to study the movements of heavenly bodies the following activity is suggested.

Suppose in your house it is possible to look at the northern sky through a window. If the window is on the first floor that will help in noting the sky better. Keep a chair at a particular position in front of the window so that by sitting in that chair you can get a view of the sky In order to help you to look at the sky at a definite angle fix a scale to the chair so that it always touches your shoulder or your ear. If there are some grill works giving fixed frames in the window that will help you to note the position of stars and planets, etc. Observe the sky every Sunday at 7.30 p.m. (It would be better if three or four children group together in a house so that they can locate and discuss their positions with reference to the fixed frames in the window). Continue this type of observations for about 8 weeks. You are sure to notice the change of positions of stars. You will also notice the rapid change of positions of the moon along with changes in its shape.

In which direction does the moon shift with reference to stars ?
How are you going to locate the position of the sun in the Zodiac belt ?

The sun seems to move or drift eastward more slowly. The day-to-day drift can be estimated by looking at the night sky at the time of sun set. The constellation at the east seems to rise a few minutes (four minutes) earlier each night. By the time the sun migrates completely towards the east in the sky one complete year will pass On March 21, the sun will be associated with the first point of Pisces, June 21 in Gemini, September 23 in the first point of Virgo and in December 22 in Sagittarius.

If a person observes the movements of planets such as Mars for a few months one will notice that the movement changes direction as well as speed. Planets seem to move eastward relative to stars for most of the time but at times their motions reverse and briefly move westward. This retrograde motion of Mars could be understood with reference to Fig. 34.8.

One must recall that planets move around the sun in definite orbits. The orbits of inner planets could be taken as nearly

circular. The period of rotation of the earth and Mars around the sun are different When our earth completes one revolution Mars would cover only half of its rotation (Mars takes 1.88 years for one revolution). Because of this the line joining to earth and Mars makes different inclinations with reference to fixed stars. Refer fig. 34.8. You can infer from the figure that between the months of May and August the direction of motion will be reversed.

3. Phases of the Moon

Moon is one of the prominent heavenly bodies in the sky. Only during the Full Moon day the moon rises from the eastern horizon when the sun sets. On subsequent nights it seems to rise from the eastern horizon sometime after the sunset. If the moon rises late in the night naturally it will not be seen setting in the west when sun rises in the morning Alongwith the delay

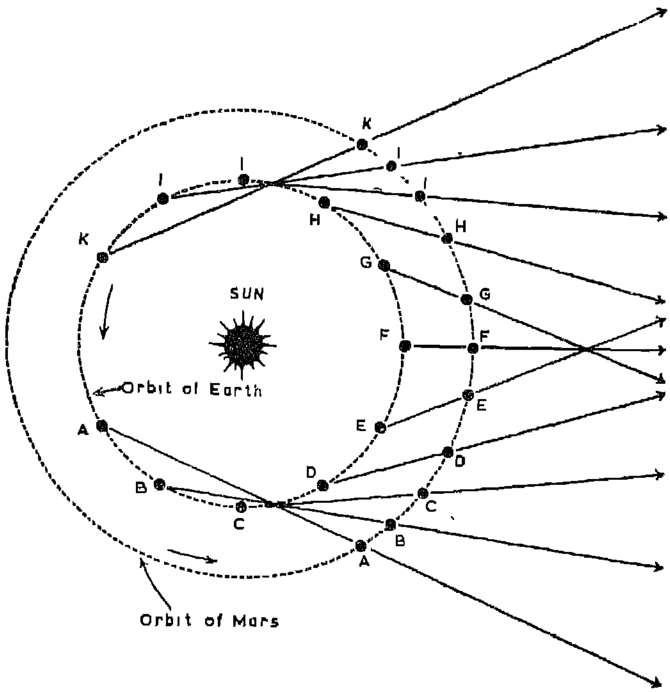

Fig. 34 8(*a*). Mars' orbit

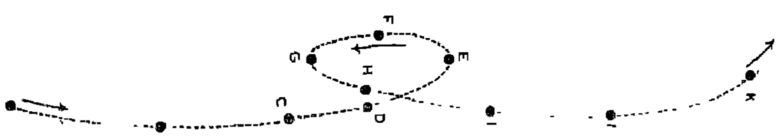

Fig. 34.8(*b*). Retrograde motion

in rising, one can also notice changes in the moon's shape. Refer figure 34.9 (b) which represents the shape and the position of the moon close to sun set. A day will come where no moon is seen in the sky On subsequent nights crescent moon is seen towards the western sky. Refer figure 34.9 (a).

The phases of moon could be explained in terms of its revolution round the earth. It takes about $29\frac{1}{2}$ days to complete one rotation which is about a month. This means, the moon shifts about 12° towards the east every day In about a week, it will shift 90° and will be seen overhead having a shape of Quarter moon

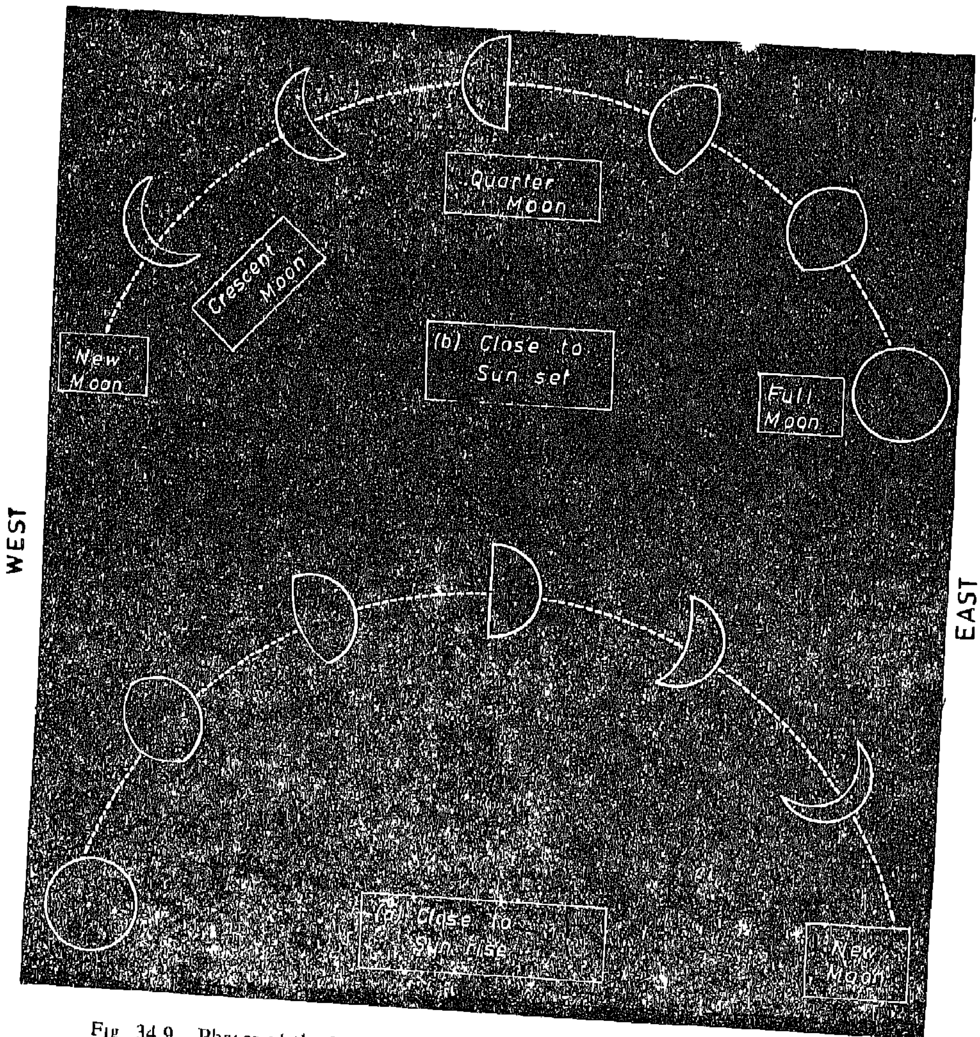

Fig 34 9 Phases of the Moon—(a) Close to sun rise, and (b) Close to sun set.

Pupil's Activity

Activity The phases of the moon could be understood by the children from the following school activity

Blow a balloon and paint it with white emulsion paint. Suspend the balloon in a dark room at about 2m height. Fix a torchlight at that height so that its light falls normally Walk around the balloon in a circle and study the illuminated balloon. When you face the balloon from the side of the torch you notice the full half portion illuminated representing a picture of a full moon Walk around the balloon so that the line joining the light and the balloon and your eyesight towards the balloon makes 90° You will notice only a quarter of the balloon illuminated When you walk further so that the balloon is midway between you and the torch you will notice only a very thin portion of the illuminated balloon. This represents a crescent moon Walk further towards the torch—the crescent shape changes increasing the illuminated portion showing the appearance of quarter and full moon.

This activity gives a picture of what would happen when there is relative motion between the moon and the earth keeping the sun fixed at a point Actually the moon revolves round the earth. The activity with the observer at the centre and the illuminated balloon rotating in a circle will also give the same appearance of quarter, crescent, etc. But in practice it is a bit difficult to rotate the illuminated balloon around an observer.

Testing Pupil Achievement

1. Regulus is a blue-white star in Leo constellation and Antares is a red star. Which star has higher temperature ? Give reasons.

2. What is the difference between (*i*) inter-planetary space and inter-stellar space ? (*ii*) Inter-galatic space and inter-stellar space ?

3. What information a scientist wishes to gather during the total solar eclipse ?

4. Why is it difficult to see the planet Mercury ?

5. What is the phase of moon at the time of (*i*) Lunar eclipse, and (*ii*) Solar eclipse ?

6. On which day(s) of the year the length of the shadow of a vertical pole becomes shortest at noon ? (Pupils are made to observe the shadows of vertical objects mounted in the playground).

7. The apparent motion of the constellations is due to the rotation of the earth. How do you account for the relative motion of the sun which seems to migrate eastward with reference to the constellations ?

Method Used

In this chapter the field-study-cum-inquiry method is used. You may make a list of pupil activities that can be performed in the field on the topic of this chapter. You may encourage the pupils to improvise apparatus to study the night sky. Also you may give them a set of questions which can be answered only after the pupils have performed activities in the field If a telescope is available you may have the pupils use it. It may be best to focus the telescope on some heavenly body and let the students look at it one by one. Later on you may give them group assignments where a group of 5-6 mature pupils take the telescope out and collect data. It will be necessary to

give instructions for proper use, safety and maintenance of the apparatus that is taken out.

Several topics in science can be better taught by field-study-cum-inquiry method. Think of the large number of activities pupils can do in the field outside the school hours You may suggest such activities to pupils at the end of each chapter, if possible.

Assignments

(*i*) Whenever a top spins it will have precession motion. Will there be such precessional motion with reference to our earth ? If so will the Polaris be seen always above the earth's axis of rotation ?

(*ii*) Why does the Milky Way look very bright during summer nights and not so bright during the spring ?

(*iii*) Prepare a model out of plastic or clay or paper 'mesh' to indicate the sizes of (i) the Earth and Jupiter and (ii) Jupiter and the Sun.

(*iv*) Draw a chart of the Solar system indicating the distance in terms of time needed for a radio wave transmitted from the Earth to reach different planets and the sun

(*v*) Have pupils take photographs of the rising sun on 20th of every month keeping some good reference object like an electric pole or a tower of a building in the east Plan your activities using these pupils' photographs while teaching a unit on 'Revolution of the Earth'.

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CHAPTER 35

Wave Motion

Introduction

The concept of wave motion is basic to physics at all levels. Nearly half of our sensory experiences are related with some type of wave motion. As you are reading this, light waves are falling on your retina which are communicating what is written here to your brain through electrical waves. When you teach in the class, you communicate your ideas to your pupils using sound waves. The teaching of such an important basic concept of wave motion should be both interesting and challenging particularly with respect to various science-teaching methods. We shall attempt here to discuss the various methods suitable for the teaching of major concepts about wave motion. These methods are (*i*) demonstration-cum-discussion, (*ii*) lecture-cum-discussion and (*iii*) pupil activity methods.

Major Concepts

The major concepts in this unit are as follows.

(*i*) Periodic disturbances produce sustained wave motion.

(*ii*) Waves carry energy.

(*iii*) Velocity of waves depends upon its medium

(*iv*) Electromagnetic waves do not need any medium for propagation.

(*i*) The basic factor underlying the first concept is the fact that any disturbance at a point in a continuous medium produces, without actual transfer of matter, a series of similar disturbance in all directions with the passage of time and that the intensity of these disturbances decays continuously. And if these have to be sustained then the disturbance should also continue in a regular manner. Thus, for example, if you throw a stone in still water,

you momentarily create a 'trough' in the medium at a certain point which gives rise to a series of crests and troughs in all directions as the time passes and the intensity of such crests and troughs dies away as it goes farther and farther from the starting point Therefore, if this series of crests and troughs which constitute wave-motion has to continue, the stone should be thrown at regular intervals so that the next crest reaches before the first dies out.

Cite other examples of periodic disturbance giving rise to wave motion

(*ii*) As a moving object has energy and it is able to do work, all waves can make things move. Hence they have energy You must have seen water waves moving things up and down In all wave motions the energy transferred to the medium by the source of disturbance is propagated along the direction of motion of the waves. When a jerk is given to a rope or a stone is dropped in a pool of water, the kinetic energy is transferred to the moving particle near the point of disturbance. These particles vibrate with a part of the received kinetic energy and the remaining energy is transferred to the particles of the next layer

How can you show that sound waves carry energy ?

(*iii*) You may be familiar with the fact that waves travel with different velocities in different media. The velocity of a wave is the characteristic of the medium only. For example light travels with different velocities in different media This gives rise to the phenomenon of refraction. Sound has very high speed in solids and lower speed in liquids and lowest in gases That is why you can hear the approaching train earlier by putting your ear to the rails. You must have studied that the velocity of elastic waves on stretched wire is proportional to $\sqrt{T/m}$ where T is that tension and m is the mass per unit length of the wire In general the velocity can be shown to be proportional to $\sqrt{S/P}$ where S is the stiffness factor and P is the density factor. Stiffer the medium faster it can respond to any disturbance because of larger restoring forces. Similarly thinner the medium the individual particles of the medium move faster and result in the increase of the speed of propagation The meaning of S in various situations is summarized as follows :

Type of wave motion	*Stiffness factor*
1. Waves on string and wire	Tension, T
2. Pressure waves in fluids (liquids and gases)	Bulk modulus, B
3 Waves in solids	Young's modulus, Y

(iv) Unlike other waves, electromagnetic waves do not require any medium for their propagation. This is why we can get light from the sun and the stars but do not receive any sound of the frequent explosions taking place there. This property of electromagnetic waves has made the short-wave satellite communication as well as communication with the space-ship possible

Generalised Characteristics of Wave Motion

Wave motion as opposed to the motion of a particle is a cooperative phenomenon occurring all over the medium or in space. It gives rise to certain periodic changes in some physical entity related to the medium or in space. For example in case of waves in material media, these changes are related with the particles of the medium and in the case of electromagnetic waves these are mutually perpendicular electric and magnetic fields. Although the physical entity is different in different waves, there are certain important characteristics common to all wave motions.

(i) Wave motion gives rise to periodic changes in some physical entity with time at a given point in space or in a medium.

Wave motion	*Physical Entity*
1 Water waves	Displacement of water particles
2. Sound waves	Displacement of particles of the medium
3 Electromagnetic waves	Mutually perpendicular electric and magnetic fields

The minimum time after which the motion is repeated is called period T and the number of times the motion is repeated in unit time is known as frequency.

What is the mathematical relationship between the period and frequency ?

(ii) If you take an instant photograph or if you just look at the waves produced on water, you will find that the displacement of water particles vary periodically with the distance. The minimum distance after which the displacement repeats is called the wavelength λ. The reciprocal of the wavelength gives us the number of waves in a unit distance and is called the wave number $\bar{\nu}$.

(iii) When a stone is dropped in water, the trough so produced in water travels in all directions with a definite speed. In other words, if at any instant the wave looks as shown in the adjoining figure by solid line, after time Δt the wave would look as shown by the dotted line.

Whatever the displacement and velocity the point A in the medium has at time Δt the same displace-

ment and velocity is produced at the point B at a distance $\triangle x$ from A after time $\triangle t$. You can say that the disturbance at A travels to B in time $\triangle t$ Thus the velocity v of the wave motion is given by $v = \frac{\triangle x}{\triangle t}$.

Fig 35.1. Movement of the wave

The distance travelled by the wave in periodic time T is λ. Thus $v = \frac{\lambda}{T}$.

Show that $v=\lambda/T$ is consistent with the fact that wave motion gives rise to changes which are periodic both in space and time.

(iv) *Types of Wave Motion*. Many of the simple waves like waves on water, on string, etc., or monochromatic electromagnetic waves are sinusoidal in nature. But this is not necessary. It can be shown that a disturbance periodic in time of any shape is equivalent to an infinite sum of sinusoidal disturbances of various frequencies known as harmonics. These harmonics are mathematically represented by the successive terms in the Fourier Analysis. Get the first ten terms for a saw tooth wave form from any book dealing with Fourier Analysis. Plot three or four (if possible all ten) on a graph paper. Then add them graphically to get a feel of what the infinite Fourier series really represents.

As you know the periodic changes of physical entity take place in a direction perpendicular to that in which the wave travels, in case of a transverse wave. Also, periodic changes take place in the same direction in which the wave travels, in case of a longitudinal wave.

Since electromagnetic waves are transverse, show by diagram the directions in which the electric and magnetic intensities change, in relation to the direction of propagation.

Method Used

For the sake of illustration let us take the concept :

Any periodic disturbance in a medium produces sustained wave motion.

Most familiar illustration of wave motion is that of waves on water. This experience can be recalled and can be demonstrated as follows · A plastic trough with an electric lamp just above or with sunlight, from the top can serve as a ripple tank. Circular waves can be produced by dropping a water drop in the centre with the help of a dropper. Through this demonstration and using the question-answer technique, following characteristics of wave motion can be extracted from the students in a qualitative manner :

(*i*) At a particular point the displacement of water particles is repeating itself in a regular way.

(*ii*) At a particular instant the displacement of water particle is same after a distance and a similar pattern is repeated.

(*iii*) The disturbance at one point moves to the neighbouring point with uniform velocity.

(*iv*) The waves die out as they go away from the source of disturbance.

The first three observations help students to learn the three characteristics of wave motion. This background can be used to give them the definition of T, λ and v. You may draw a suitable diagram on the blackboard to indicate wave motion and derive the relationship $v = \frac{\lambda}{T}$. The fourth observation tells them why the disturbance has to be periodic in order that the waves be sustained You may discuss with the students how to sustain the waves on water and thereby make them infer that the disturbance has to be periodic in order that the waves are sustained.

It will be worthwhile to let the students conclude at this stage that the basic cause for the spreading of waves is the elasticity of the medium You may use a spring to illustrate how the wave motion is propagated due to its elasticity

Some generalisation about wave motion will be in order after this These are to be brought home to the students mostly by lecture-cum-discussion method. Give illustrations of wave motion like waves in solids, electromagnetic waves, etc Discuss such questions as : Are waves generated, if so where ?—(i) when we speak, (ii) when we strike an iron rod, (iii) when we light a lamp ? The idea about wavelength, frequency and velocity of different types of waves is also to be given. Students may be asked to give as many illustrations as they know of wave motion in order to give full play to their creativity.

Testing Pupil Achievement

Following samples of objective and descriptive questions may help you to frame your own questions for evaluation :

1. Define wavelength.
2. If the time period of a wave motion is 10 ms, what is its frequency ?
3. How much distance a wave travels in one period ? What is this distance called ?
4. Give ten examples of periodic motion ?
5. What is the period for a particle moving in straight line with uniform velocity ?
6. Why the following cannot be wave motion ?
   (*i*) A swinging pendulum
   (*ii*) Merry-go-round
   (*iii*) A falling stone
7. Wavelength of a radio-wave is 30 m. If the velocity of light is 3×10^8 m/s what is the frequency of this radio-wave ?
8. On your radio or transistor, wavelength in meters and frequency in kHz is given. Read both of these at 10 positions of the tuner. Note them down in a tabular form. Multiply each pair What conclusion can you draw ?
9. What is the frequency of monochromatic light with wavelength 5890 Å ?
10. Taking a suitable scale, plot the following wave equation for x=0

ment and velocity is produced at the point B at a distance $\triangle x$ from A after time $\triangle t$. You can say that the disturbance at A travels to B in time $\triangle t$. Thus the velocity v of the wave motion is given by $v = \frac{\triangle x}{\triangle t}$.

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It will be worthwhile to let the students conclude at this stage that the basic cause for the spreading of waves is the elasticity of the medium. You may use a spring to illustrate how the wave motion is propagated due to its elasticity

Some generalisation about wave motion will be in order after this These are to be brought home to the students mostly by lecture-cum-discussion method Give illustrations of wave motion like waves in solids, electromagnetic waves, etc. Discuss such questions as : Are waves generated, if so where ?—(i) when we speak, (ii) when we strike an iron rod, (iii) when we light a lamp ? The idea about wavelength, frequency and velocity of different types of waves is also to be given. Students may be asked to give as many illustrations as they know of wave motion in order to give full play to their creativity

Testing Pupil Achievement

Following samples of objective and descriptive questions may help you to frame your own questions for evaluation :

1 Define wavelength.

2. If the time period of a wave motion is 10 ms, what is its frequency ?

3. How much distance a wave travels in one period ? What is this distance called ?

4. Give ten examples of periodic motion ?

5. What is the period for a particle moving in straight line with uniform velocity ?

6. Why the following cannot be wave motion ?
   (*i*) A swinging pendulum
   (*ii*) Merry-go-round
   (*iii*) A falling stone

7 Wavelength of a radio-wave is 30 m. If the velocity of light is 3×10^8 m/s what is the frequency of this radio-wave ?

8 On your radio or transistor, wavelength in meters and frequency in kHz is given Read both of these at 10 positions of the tuner. Note them down in a tabular form. Multiply each pair. What conclusion can you draw ?

9 What is the frequency of monochromatic light with wavelength 5890 Å ?

10. Taking a suitable scale, plot the following wave equation for x=0

as a function of t and then taking t=0 as a function of x.

$$y=5 \sin 2\pi \left(\frac{x}{2.5} - \frac{t}{0.01} \right)$$

Method Used

The demonstration - cum - discussion method used in this chapter will give optimum results if a ripple tank of large size is used. What should be the dimensions of the tank and the source for good demonstration ? You may make sure that all the items needed for the demonstration are in usable condition You may wish to try out the demonstration experiment yourself before taking it to the classroom What adjustments are required for giving a successful demonstration using a ripple tank ? Preferably all the necessary adjustments may be done ahead of time

The ripple tank used in pupil activity has smaller dimensions. What should be the smallest size of the tank and the source for pupil activity ? Instructions for proper adjustments may be given to pupils orally or 'better' in writing. If the write up is given about one week ahead of time, it will save some laboratory time

Assignments

1. Write down a lesson plan for teaching the concept "Waves carry energy".

2. How will you use a spring to bring home the concept : 'Disturbance in a medium causes wave motion due to elasticity of the medium?'

3 Out of the questions given in section 6, which are recall-type and which are application type ?

4. The demonstration mentioned in section 5, can be given as pupils' activity Comment on this suggestion.

5. What strategy would you employ to infer that electromagnetic waves carry energy ? (Consider interconversion of energy).

6. How can you give the pupil an idea of the size of the wavelength of light ? (Compare with the size of the molecule).

7. Make a teaching aid for illustration of wave motion

8. Prepare a chart showing the wavelengths of electromagnetic waves ranging from gamma rays to radio-waves.

9 Comment on the following sequence of activities for teaching the unit of wave motion Resequence as you would yourself like to do Give reasons for your choice

(*a*) Show the PSSC film on simple waves.

(*b*) Introduce the idea of periodic motion.

(*c*) Give the example of waves in water

(*d*) Demonstrate how waves propagate in a spring

(*e*) Recall pupils' experiences about waves

10. Criticize the following as an illustration of wave motion ·
Stopping and starting of a series of cars at a traffic signal.

11 Try to demonstrate using a slinky that the velocity of a disturbance depends on the medium Keeping in view the relation $v=\sqrt{T/m}$, what difficulties can you envisage ?

12 Use Cathode Ray Oscilloscope attached with a microphone to see the wave form produced by

(*i*) A whistle

(*ii*) A speech

(*iii*) A tuning fork

(*iv*) Ticking of a watch

13. Write in simple language satisfactory answers for the following queries of the pupils.

(i) Every wave motion is due to vibration of some source. What vibrates in case of electromagnetic waves ?

(ii) Waves spread because of elasticity of the medium But how do electromagnetic waves spread in vacuum ?

14 In how many ways you can classify waves in general ? State the rationale for each classification.

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CHAPTER 36

Work and Energy

Introduction

This unit introduces the concept of work which in turn leads on to the more important concept of energy. Both are important and crucial ideas that need to be developed with care. It is essential that students are fully familiar with the quantitative use of the expression for energy since this is useful not only in mechanics but throughout the study of physics. The principle of conservation of energy is one of the most powerful tools for solving a wide range of problems in physics particularly those where the forces of interaction are unknown.

We hope this unit will help you to

1. understand the concepts of work and energy and their interrelationship.
2. understand the energy transformation and the conservation of mechanical energy.
3. plan pupil activity.
4. analyse the major concepts.

Major Concepts

1. Work is defined by the product of the force acting and the displacement produced in the direction of the force.
2. The kinetic energy of a body of mass moving with a velocity V is $\frac{1}{2}mV^2$.
3. The change in the kinetic energy of a body is exactly equal to the work done.
4. The potential energy of a system of interacting bodies depends only on their separation
5. Kinetic energy can be transformed into potential energy and vice versa.
6. Mechanical energy is conserved for systems in which other forms of energy play no part.
7. Mechanical energy can be converted to other forms of energy.

Definition—'Works' Remember that 'Work' is defined by the expression W= force acting X displacement produced in the direction of the force. From the definition it is obvious that work is directly proportional to (i) the magnitude of the force and (ii) the displacement in the *direction of the force*. Note that the term "work" used in physics is not exactly the same as 'work'

used in everyday language. The definition also implies that :

(*a*) A force which does not move an object does no work.

(*b*) The quantity of work is independent of the time a force acts.

(*c*) No work is done when the displacement is perpendicular to the direction of Force.

(*d*) Displacement refers to the displacement taking place during the action of the force.

To make these ideas clear you may have to discuss a variety of jobs and the work done in each case. Fuel consumed is a good measure of the work done, and this will help you to develop the correct concept of work

1. If work done in two instances is equal does it follow that the displacements also are equal ?

2. A stone is tied to a string and holding the other end the stone is whirled in a horizontal circle with uniform speed. What is the work done in one revolution ?

Kinetic energy . Kinetic energy is defined in terms of the mass and velocity of the body This represents the energy of motion of the body Even though kinetic energy is exactly equal to the work the body can do before coming to rest, we *should not* give a general definition of energy as 'the capacity to do work'.

1 By how much is the kinetic energy increased if the velocity is increased three times ?

Relation between the work done and the change in kinetic energy :

This is a very useful relationship and should be understood clearly by the pupils. Work out several numerical examples to show that the *same work* will always produce the *same change* in kinetic energy of the object no matter what its initial energy is.

At this stage you should be able to differentiate between momentum and kinetic energy both of which are properties of motion. This is best done by taking an example where the same work is done on two different masses. Show that there is the *same* increase in kinetic energy but *not the same* increase in momentum.

A carrom coin hit by the striker moves 40 cm before coming to rest Assume that the force of friction is the same throughout.

1 Is the change of *kinetic energy* the same in the first 20 cm as in the next 20 cm ?

2 Is the change of *momentum* the same in the first 20 cm as in the next 20 cm ?

Potential energy of a system · We define potential energy for particles which *interact* with each other such as charges or masses You can speak of potential energy for a body raised above the ground level *or* for a stretched spring. In the former the gravitational force, and in the latter the elastic force of the spring provide the force of interaction.

The gravitational poteetial energy of mass m at a height h above the ground is defined to be 'mgh'. It is very important to show that the potential energy of a mass at a given height is always the same no matter how it got there. Establish this by choosing several paths from the ground level to the height h, and calculating the work done in each case

A spring is suspended vertically. It can be stretched by adding 200 gm to it by loading (a) with a single mass of 200 gm in one step

or (b) first with a mass of 50 gm and then adding an additional mass of 150 gm in ***two steps.***

Will the final potential energy of the spring be *the same* in both the cases ? Why ?

Energy Transformation After defining the two types of energy you can take up the possibility of converting kinetic energy to potential energy and vice versa Explain this with the aid of examples such as the falling body, the bob of an oscillating pendulum etc. It is necessary to clarify this concept before you take up the law of conservation of energy.

Conservation of Mechanical Energy · This is a very powerful principle used extensively in physics to solve many complex problems. You can derive this principle in the case of a falling body, or a body sliding down an inclined plane *or* you can demonstrate the truth of this principle by an experiment.

Types of Energy Point out to the pupils that there are other forms of energy besides mechanical energy such as chemical, electrical, heat, and nuclear Only examples need be given.

Methods Used

You can try the *Pupil Activity* method for establishing the principle of conservation of mechanical energy.

Set up a long simple pendulum (about

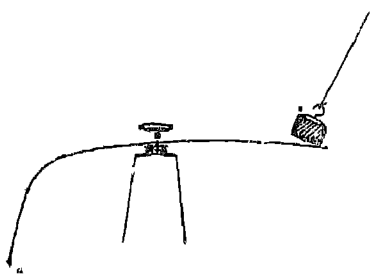

Fig. 36 1. Pendulum tape-timer arrangement

2-3 m long) from the ceiling, with a heavy bob (about $\frac{1}{2}$ kg). Set up a tape timer on a stool on one side of the pendulum Pass a tape through the timer and fix its end to the lower end of the bob as in figure 36.1. Take the bob to a side and release it so as to get a record of the motion on the tape.

Take several tapes and distribute the tapes among the students. The class can be divided into groups and each group could be given a tape.

Instruct each group to observe the spacing of the dots carefully and to answer the following questions :—

(*a*) How does the speed of the bob change from one end to the other end ?

(*b*) What do you conclude from this regarding the kinetic energy of the bob ?

Students can easily notice that the spacing between dots increases gradually up to the middle region and then decreases gradually towards the other end Point out that the time interval between successive dots is always the same With this hint students can conclude that the kinetic energy of the bob first increases and then decreases This step confirms that the kinetic energy of the bob undergoes continuous changes

(*c*) What happens to the potential energy of the bob as it goes from one end to the other ? Students can easily observe that the potential energy decreases and then increases.

Now you have established that both kinetic and potential energies of the bob are undergoing continuous changes The next step is to calculate the two types of energy.

(*d*) How can you calculate the kinetic energy of the bob at some position ?

Instruct students to choose some point such as P on the tape for calculation of kinetic energy. See Fig. 36 2

Fig 36 2 Dots on the tape

The actual velocity at P is $=\frac{PQ}{t}$ where t is the time interval between successive dots Hence the kinetic energy at P$=\frac{1}{2} m\frac{PQ^2}{t^2}$. How can we find t? [Hint : By timing the motion of the bob from A to B]

(*e*) How can you calculate the potential energy of the bob at some point such as P ?

To calculate this, draw the figure of the pendulum as given below in Fig 36 3 The potential energy at P$=$mgh

To find 'h' .—

$$OD^2+PD^2=OP^2$$
$$(l-h)^2+PD^2=l^2$$
$$l^2-2lh+h^2+PD^2=l^2$$

Neglect h^2 which is very small.

$$2lh=PD^2$$
$$h=\frac{PD^2}{2l}$$

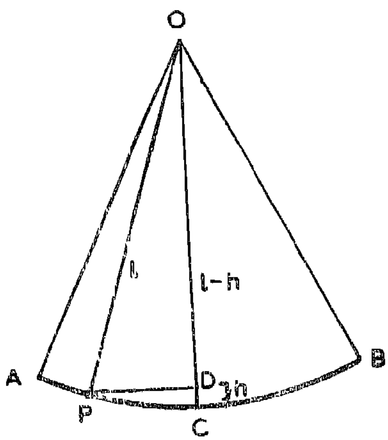

Fig. 36.3. Motion of the pendulum

'l' can be directly measured How can you measure PD, the distance of the point P from the equilibrium position C ? The mid-point between A and B on the tape could be taken as C so that PC on the tape measures PD

(*f*) Ask the students to calculate the kinetic energy and the potential energy at a few points on the tape and to find the sum of the two energies in each case The sum will come out to be *approximately* constant at all points and not exact Where is the source of error ?

Method Used

For teaching the topics of this unit it is necessary that the concepts are carefully developed For example the distinction between work and energy should be carefully brought out. Some numerical examples using SI system will be useful. You may stress that 'work' has special meaning in physics. You may actually compute work in several different cases

The pupil activity method will be most effective if the students take data individually and later discuss results with each other. The use of this method has already been discussed in previous chapters

Assignment

1. Plan activities for pupils to get a 'feel' of 1 Joule of Work (e g. by lifting a known weight)
2. Plan demonstrations to show that energy can be stored in biological, chemical or physical systems
3. List the processes in nature which are best suited to illustrate energy conversions
4. The text book defines work first and then introduces energy. Can you

start with energy and then introduce work ? Write a unit plan to develop the concepts in this sequence.

You may refer to the PSSC Physics —Textbook and Teachers' Guide

5 Energy and momentum are both properties of motion. What activities *or* demonstrations would you use to differentiate between them ?

6. How would you convince the pupils that .

(*a*) a force which does not move an object does no work

(*b*) no work is done when the displacement is perpendicular to the direction of force.

Refer to—Nuffield Physics—Teachers' Guide Vol. 1.

7. Set up simple demonstrations to show energy interconversions to your class. (e.g. Chemical to electrical to mechanical).

8. When you fall from a height, you get hurt. What causes the injury ? Is it due to ·

(*a*) the *force* of impact ?

(*b*) transfer of *momentum* ?

(*c*) transfer of *energy* ?

How would you conduct a discussion in the class to find an answer to this question ?

9. Write down two items to test the differentiation between momentum and energy

10. Extension or compression of a spring depends upon the work done. Use this idea to make an 'Energy Meter'.

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CHAPTER 37

Floatation

Introduction

Floatation of a body in a fluid (liquid or gas) is a matter of common experience. You might have seen that it is much easier to lift a bucket full of water when it is under water in a well than when it is outside. Any object whenever immersed in a fluid appears to be lighter. The immersed body suffers an apparent loss of weight due to the property of buoyancy of fluids. The body experiences an upward buoyant force due to the net upthrust of the fluid which supports a floating body. The net upthrust arises due to the difference between the large magnitude of the upward force at the bottom surface of the immersed body and the smaller downward force on its upper surface. The upthrust experienced by a body is equal to the weight of the fluid displaced by it. This is known as Archimedes' principle that plays an important role in determining the conditions of floatation and the forces which keep the floating body in equilibrium. It has many applications in determining the relative densities of materials and in designing of hydrometers, lactometers, ships and submarines.

In this unit, we will discuss how the principle of Archimedes can be developed through pupils' activity by finding out the fluid upthrust experienced by the body and the weight of the displaced fluid.

Major Concepts

(*i*) A fluid exerts a buoyant force on the body immersed in it.

(*ii*) The buoyant force experienced by the body is due to the upward thrust of the fluid and supports the floating body.

(*iii*) The apparent loss of weight of the body suspended in a fluid is independent of the mass of the body.

(*iv*) The buoyant force is equal to the product of weight, density and

volume of the displaced fluid.

(v) Archimedes' principle can be verified by finding out the weight of fluid displaced by the body and the buoyant force experienced by it.

Development of the Concepts

You will use the pupils' activity method to demonstrate how the upward buoyant force experienced by an immersed body arises in a fluid and on what factors it depends. In this method, we plan and provide some activities to the pupils through which they can learn the underlying principles more effectively by 'doing' While the pupil is performing the activity, the teacher may ask him suitable questions to judge the understanding of the subject matter to help him obtain a generalisation. To find out what affects the fluid upthrust, you may perform the following activities.

Look at the diagram of the 'force meter' as given in Fig 37.1 and construct an improvised one with hook arrangement Use the force meter to find out the liquid upthrust experienced by a set of bodies and the weight of a set of liquids displaced by them, collected in overflow Jar.

For this purpose you will need :

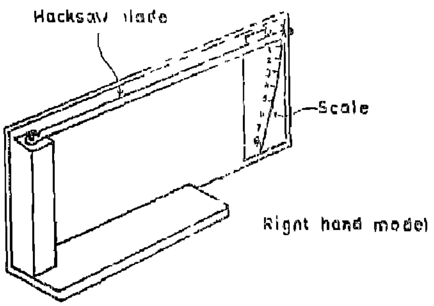

Fig. 37 1 Force meter.

(a) a set of three objects (B_1, B_2, B_3) of the same volume but different masses. You can use three very small identical injections (Penicillin), a medicine bottles with rubber stoppers to make them air tight and fill them with proper quantities of sand, lead shots and water respectively.

(b) a set of three objects (B_1', B_2', B_3') of the same mass but different volumes You can make three bottles of different sizes with lids and fill them with appropriate amounts of sand, lead shots and water respectively

(c) a set of three beakers each containing easily available liquids in large quantities having different densities. You can use water, kerosene and turpentine oil

(d) an overflow Jar and a collecting vessel with hook arrangement.

1 A body immersed in a fluid experiences an upward force.

Tie an object (bottle B_1' containing sand) to the force meter and find its weight in air by noting the reading. Immerse the object partly in the beaker containing water and note the reading. What do you find ? Immerse the object completely inside the liquid and observe the reading. What do you observe ? Change the position of fully immersed body to greater depths under the liquid and note the readings. Tabulate the data as in Table 1 What conclusions do you draw from your observations ?

Table 1

Weight of object (bottle B_1') in air=W (N)

Position of object in the liquid	*Weight of the object* W'	*Upthrust* $T=(W-W')$
	(N)	(N)
Partly immersed		
Completely immersed		
deeply to positions (i)		
(ii)		
(iii)		

2 The fluid upthrust depends directly on volume of the body by keeping the mass constant.

Suspend one of the bottles (B_1') of equal mass and different volumes from the hook of the force meter and find its weight W in air. Immerse the object (bottle B_1' with sand). Completely under water in a beaker and find its weight in water by noting the reading W^1 of the force meter. Repeat the activity with two other objects (B_2', B_3') containing lead shots and water respectively. Fill an overflow jar with water upto the brim and find the volume of each object, in turn, by knowing the volume of the displaced liquid using the overflow Jar. Tabulate the data as in Table 2. What conclusions do you draw from your observations.

Table 2

Object	*Bottle of equal mass containing*	*Weight in air*	*Weight in water*	*Volume* V	*Upthrust* $T=(W-W')$	*Ratio* $R=\frac{T}{V}$
		W (N)	W^1 (N)	(m^3)	(N)	(Nm^{-3})
B_1'	Sand					
B_2'	Lead shots					
B_3'	Water					

3 The fluid upthrust is directly proportional to the density of the fluid

Suspend the object (B_1) on the force meter and find its weight W in air Immerse the object completely under water contained in a beaker and find its weight W^1 in water. Repeat this activity with other liquids separately (kerosene and turpentine oil) contained in the beakers respectively Find the volume of the object with an overflow Jar. Tabulate the data as in Table 3 What conclusions do you draw from your observations ?

4. The fluid upthrust is independent of the mass of the immersed body by keeping the volume constant

Suspend one of the improvised bottles (B_1 with sand) of equal volume but different masses on the force meter and find its weight W in air by noting the reading. Immerse the object (B_1) fully inside water contained in the beaker and observe the reading W′ on the force meter Repeat this activity for the other two objects (bottles B_2, B_3 with lead shots and water respectively) Find the volume of the object by knowing the volume of the displaced liquid using the overflow Jar separately with the same force meter.

Tabulate the data as in Table 4. What conclusions can be drawn from your observations ?

Table 3

Weight of the object (B_1) in air=W (N)

Object immersed in land	*Density of the liquid d*	*Weight of the object in the liquid*	*Upthrust $T=(W-W')$*	*Ratio $R=(T/d)$*
	($Kg\ m^{-3}$)	W^1 (N)	(N)	($N\ kg^{-1}m^3$)
Water				
Kerosene				
Turpentine oil				

Table 4

Object	*Bottle of equal volume containing*	*Weight in air W*	*Weight in water W′*	*Upthrust $T=(W-W')$*
		(*N*)	(*N*)	(*N*)
B_1	Sand			
B_2	Lead shots			
B_3	Water			

5. *Verification of Archimedes' principle.*

In the activity 3 determine the volume (V) of the object with an overflow Jar. Fill the overflow jar with water upto its brim. Immerse the object (B_1) completely under water and collect the overflowing liquid in a vessel. Find the weight W_1 of this displaced liquid separately with the same force meter. Repeat this activity with the other two liquids (Kerosene and turpentine oil).

Tabulate the product $W_1=Vdg$ against the observed upthrust $T=(W-W')$ from the activity of Section 4.3 taking $g=9.8\ ms^{-2}$ as in Table 5. What do you establish from all your earlier observations?

Table 5

Weight of the object (B_1) in air=W (N)

Object immersed in liquid	*density of the liquid d*	*Volume of the object V*	*Weight of the object in liquid W'*	*Liquid upthrust $T=(W-W')$*	*Weight of the displaced liquid*	*Ratio $R=(T/W'_1)$*
	($Kg\ m^{-3}$)	(m^3)	(N)	(N)	$W_1=Vdg$ (N)	
Water						
Kerosene						
Turpentine oil						

Test materials for evaluating pupil's achievement

Following questions and exercises may be used to judge the pupil's understanding of the subject matter.

1. Define the term 'buoyancy'.
2. What is 'liquid upthrust'? Give reasons for the apparent loss of weight of a body immersed in a liquid in terms of liquid upthrust.
3. How can you explain that the same body displaces more weight of water than kerosene oil. Give reasons in terms of buoyant force.
4. Explain how you can measure the buoyant force.
5. Does liquid upthrust depend on the mass of an immersed body in a liquid?
6. State Archimedes' principle.
7. Prove Archimedes' principle for a cube immersed in a liquid.

Method Used

In this chapter pupil-activity method is discussed. The detailed suggestions on the use of this method have been given in the previous chapters. What precautions will you suggest the pupil take for the activities of this chapter? You may give them instructions on proper handling of apparatus and safety rules. You may also remind the pupils to use properly their skills of observation, data collection and recording of data. Can you think of some more home activities related to the topic of this chapter?

Assignments

1. Prepare an improvised force meter and use it to launch carrom coins.
2. Construct an improvised hydrometer out of a waterproof straw.
3. Construct an improvised cartesian diver and use it to illustrate the principle of floatation.
4. Improve automatic flush.
5. Explain why its level rises when a ship enters sea waters from fresh waters.
6. Prepare an improvised apparatus to illustrate the principle of submarine.
7. Prepare a simple apparatus to illustrate the principle of formation and rise of balloon using a soap solution.
8. List some of the industrial uses of the principle of floatation.
9. Explain the rise of napthalene balls in acetic acid sodium bicarbonate solution.
10. What change do you observe when an egg is placed in the jar of fresh water and then some salt is added to water and stirred ?
11. Prepare a lesson plan on 'floatation' from the following activities in cronological order.

Pupils' weigh objects in and out of water

....

Pupils' copy a statement of Archimedents principle

....

Pupils measure the overflowing water when an object is immersed

....

Pupils hear the teacher telling the story of Archimedes

....

Teacher derives a mathematical proof of Archimedes principle on the board

....

Teacher shows a chart of a submarine

....

(other)

....

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PROFORMA FOR FEEDBACK

After using the book, we shall appreciate if you fill out the questionnaire given below and send it to the following address :—

Head,
Department of Teacher Education,
NCERT, Sri Aurobindo Marg,
New Delhi-110016.

QUESTIONNAIRE

1. What features in this book you like the best ?

....

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2. Give reference to page numbers and paragraphs which you could not understand and want to be clarified further ?

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3. Did you find the projects and activities listed at the end of each unit useful ? Could you perform any of them ?

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4. Give any other suggestions for the improvement of this book ?

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